BIOLOGY

PART I

SCIENCE FOR MIDDLE SCHOOLS

TUTE OF EDUCATION
CALCUTTA

NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

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SCIENCE FOR MIDDLE SCHOOLS

INSTITUTE OF EDUCATION FOR WOMEN
Dept. of Extension
SERVICE.
CALCUTTA-27

NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

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FOREWORD

In the second half of the twentieth century, the importance of science and technology to every nation does not need to be argued. It is evident to the most casual observer. The explosive expansion of fundamental scientific knowledge that began in the first half of the century is a potential source of enduring improvement in the nation's economy, capable of bringing to every citizen more food and water, better clothing and shelter, greater opportunities for education and wage-earning and, in general, a healtheir, safer and more rewarding life. But, if a nation is to be able to exploit modern science and technology, it must have men and women competent to do fundamental scientific research and men and women competent to translate the resulting knowledge into means for improvement of the national economy.

What is true of all nations is true in a special degree of developing societies such as India's. If the recognition of one truth in education in the twentieth century is more valuable than any other, it is that education is the most potent instrument for change anywhere. India, the developing society *par excellence*, is at the stage of having to pull herself up by the bootstraps out of the rut of a traditional society to move swiftly and effectively into the orbit of modernity that is a precondition of national survival.

Improvement in the total standard of science and mathematics is a continuous process that demands three integrated steps, and the process begins necessarily at school level. It moves as follows :

(*a*) Development of a curriculum that includes modern concepts and understandings of the subject-fields and a rigorous, analytic study of fundamentals.

(*b*) Preparation of textbooks based on the new curriculum; teachers' guides and manuals and other instructional materials; development of experimental kits and appartus.

(*c*) Training teachers to enable them to introduce the new curriculum into the classroom.

Science in some form or other, either as general science or as everyday science, is being taught in all our middle schools. It has, however, been realized by all scientists and educationists that the teaching of general science at the middle school stage is inadequate since it does not provide a firm foundation for the understanding of the basic concepts of physics, chemistry and biology. The Education Commission (1964-66) has observed that "the general science approach to the teaching of science which has been widely adopted at the elementary stage during the last ten years has not proved successful as it tends to make science appear somewhat formless and without structure and runs counter to its methodology. A disciplined approach to science learning would, it is felt, be more effective in providing the necessary scientific base to the young pupil".

A detailed survey of the present position of science and mathematics in our schools was also carried out by the National Council of Educational Research and Training. It revealed serious shortcomings. The curriculum is for the most part dated. It does not include modern concepts on the understanding of science. In mathematics the emphasis is on developing skills and not on a disciplined understanding of the basic fundamentals of the subject. No organic relationship exists in the teaching of the biological sciences, physical sciences and mathematics; each falls into a separate pigeonhole. The textbooks used are of poor quality. Teachers have not been provided with manuals, guides and other instructional materials. Laboratory apparatus and equipment are still of the conventional type and unsuited to teaching science along modern lines.

A team of Soviet science educators visited India about three years ago and put in a report on the lines on which science and mathematics education should be improved in India's secondary schools. They recommended that instead of teaching general science, the individual disciplines of science structured as physics, chemistry and biology should be taught from the very beginning of the middle school stage.

Following upon these surveys and reports, the Department of Science Education in the National Council of Educational Research and Training has a major project to upgrade science and mathematics, starting from the middle school stage. Under this project, a new curriculum is being formulated, textbooks and teachers' guides prepared and teachers trained. For this purpose, a number of schools have been selected in Delhi where the new curriculum and other instructional materials developed by the Department are being tried out in actual situations. Science is being taught not as general science, but as physics, chemistry, biology and mathematics, that is, as separate subjects and in depth. On the basis of the experience gained, the curriculum and instructional materials are being refined and further developed for application throughout the country. The materials produced so far cover the three years of the middle school stage and have been subjected to rigorous trial and experiment in Delhi schools.

The present series of text materials now published consists of teaching units, textbooks, curriculum guides and teachers' manuals for the first year of the middle school stage. These have successfully passed through exhaustive try-outs and tests in selected schools and are now available for application throughout the country. The syllabi and text materials are based on an approach that advocates the teaching of the individual disciplines of science separately. The curriculum has a practical bias. The knowledge of science is given through experimental activities to be performed by teachers and pupils. Every care has been taken to present the correct and up-to-date facts of science and to see that the examples used are drawn from Indian situations. A variety of indigenous equipment and apparatus have been designed and produced by the Central Science Workshop of the National Council to make better instructional materials available to teachers.

The National Council is grateful to the UNESCO experts who assisted the Department of Science Education on this project. It is also thankful to the Director of Education, Delhi Administration, who very kindly provided facilities to try out the curricular materials in 30 selected schools in Delhi.

The National Council will welcome constructive comments and suggestions from teachers and others interested in science education for the further improvement of the curricular materials.

L S. CHANDRAKANT

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CHAPTER 1

THE IMPORTANCE OF PLANTS IN NATURE

§ 1. Plants

When you go out into the field for a walk you will see around you many green plants. These may be huge trees, shrubs or herbs. Most of them bear flowers, fruits and seeds. But some like the ferns in a garden do not bear any flower. When we think of a plant we usually think of only trees, shrubs or herbs. But have you ever thought what pond scum is ? You might have noticed during the rainy seasons some cobweb-like growth on your wet shoes or on old bread. What is this material ? The pond scum as well as this cobweb-like material are plants. They are simple plants and are not differentiated into roots, stems and leaves.

We see plants everywhere—on hills and mountains, in the plains, in ponds and rivers, in the sea, in deserts and even on snow. Plants of different regions differ from each other. They also differ according to the climate of the region. Many plants grow on their own in the field or in the forest. These plants are said to be wild. Among them man found some useful plants. At first he used to search for those plants and collect the useful products. But later on, he tried to grow them near his house so that he could be sure of getting the useful product. He showed much care in growing these plants. In other words, he cultivated these plants. Now man cultivates many plants. Man grows or cultivates his food plants like wheat, rice, maize and fruit trees. He also grows vegetables.

§ 2. The Significance of Cultivated Plants

Three things are basic to the needs of man. These are food, clothing and shelter. Where from do you get your food, *e.g.*, *chapati* ? Perhaps you will say your mother prepares them from flour. Where does this flour come from ? It comes from wheat grains which grow on wheat plants. You eat a mango. Where does this come from ? It comes from a mango tree.

These are many cultivated plants besides the food plants mentioned previously. Thus we have various vegetables like potatoes, *bhindi*, brinjal, tomatoes, cabbage and onion. The fruit trees like orange, apple, guava, grape, mango, etc., are also cultivated plants.

We cook many articles of food in oil. For this we use mustard oil, coconut oil, til oil, groundnut oil or some other suitable oil. All these oils are plant products. Beverages like tea, coffee, and cocoa are also prepared from plant products. We season our foods with spices and flavouring substances. Most of these are again plant products. The sugar that we use is from sugarcane, and spices like pepper, chillies, *jeera*, cloves, *elaichi*, are obtained from plants.

Our body needs various food materials like sugar, starches, fats and proteins, as also mineral salts and vitamins. To a great extent these are obtained from plants. Some people take animal products as food. But these animal products are derived from animals which again eat plants as their food. Thus we find that the plants are the main source of food for man or animal.

Clothing is an important need of man. The most widely used plant product for clothing in India is cotton. The cotton obtained from plants is spun into yarn and woven into cloth. Some plant fibres are used to manufacture artificial silk.

Timber and wood are obtained from the trunks of big trees. These are used in many ways. Ordinary wood is used as fuel. But strong and durable wood is used for making furniture.

Plants also provide us with other materials from which man makes useful products like paper and card-board from bamboo or grass, jute from the fibre of a plant, coir from the husk of coconut fruit, rubber from the liquid secreted by the rubber tree.

Plants also give us a number of drugs. Our old systems of medicine like the Ayurvedic and the Unani make use of drugs derived from plants extensively. In the western allopathic system of medicine, many drugs are obtained from plants. Some of these are quinine, belladonna, reserpin, morphia, etc.

Coal and lignite are now found buried below the layers of rock in the earth. These are remains of plants that existed long long ago and got buried under the surface of the earth. They got converted into coal and lignite. From coal many products like dyes, perfumes and drugs are now manufactured. Petroleum is also said to be the oil from minute plants and animals that existed long long ago. Their oil is now collected under some layers of rocks.

Plants play other important roles. The roots bind the soil and protect it from being washed away. The leaves falling on soil, hold back water instead of allowing it to drain off. The fallen leaves also protect the top soil from the action of running water.

What happens to dead bodies of animals and plants ? People say they decay and crumble to dust. What is this decay ? The decay is a process in which the dead body is broken into simpler substances which ultimately look like dust. This process is brought about by minute organisms called bacteria and fungi. The crumbled dust is utilized once again by plants for their growth.

All animals breathe. Because of their breathing the air gets impure. Plants also respire and add a particular gas to the air which makes it unfit for breathing. This gas which spoils the air is called carbon dioxide. If carbon dioxide is allowed to accumulate in air then many animals cannot live in such an air. But plants use this carbon dioxide in a way and convert it into food products in their leaves. In this process another gas oxygen is given out by the plants. This purifies the air and makes it again fit for animals to breathe.

The plants appeal to the aesthetic sense in man. They form part of a beautiful landscape. Plants are also ornamental and showy. Thus man is interested in plants not only for their value in giving him food, clothing and shelter but also in providing him with an element of beauty.

By a study of what a plant does, how it lives, how it grows, how it produces new plants, we gather a lot of usefu information. Such a collection of correct facts often becomes a science The study of the science of plants is called **botany.** If we study botany we understand plants much better and we can make use of our knowledge to get better varieties of plants and other useful products from plant. Thus a study of plant is very important.

§ 3. Parts of a Flowering Plant

The Mustard Plant

When you go out into the fields in the month of December or January, you will find a herb with a short erect stem and yellow flowers. This is a mustard plant. This plant resembles the radish plant.

Let us examine a mustard plant and see what parts it has. Spot an isolated mustard plant and with the help of a knife loosen the soil around the plant. Care should be taken to see that no part of the plant is injured. When the soil is loose, carefully take out the plant from the soil and gently shake it to get rid of the soil lumps. Now the plant is ready for study.

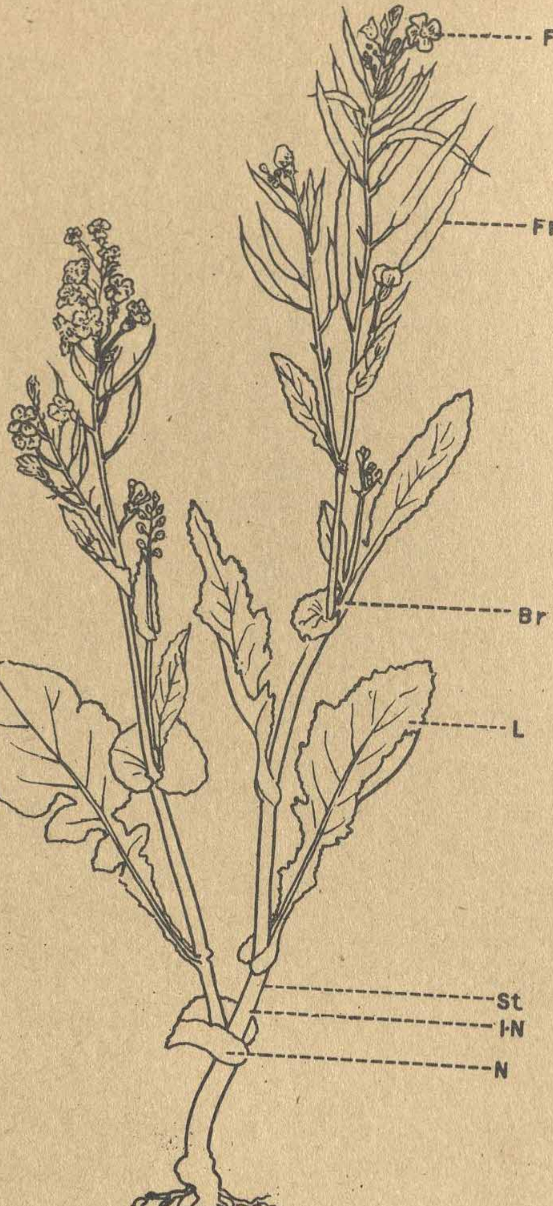

Fig. 1.1 *Mustard Plant; Fl-Flower; Fr.-Fruit; Br-Branch; L-Leaf; St-Stem; I.N.-Internode; N-Node; T.R. Tap root; S.R.-Secondary root.*

Observe the plant carefully(Fig.1.1). There are two main parts. One part is under the soil and the other above the soil. The former is pale in colour, and is the **root** of the plant. It has a main branch—the **main root**—and **lateral branches**. These roots and the branches spread in the soil. The roots, being inside the soil, absorb water and mineral salts for the plant. This is one function of the roots. Did you not feel some difficulty in uprooting a plant ? You would have used a little force to pull this plant out. This shows that the plant was firmly fixed to the soil by means of the roots. This is another function of the roots.

Now let us study the part that is above the soil. It has a short, erect, cylindrical main **stem**. It bears **leaves** and **flowers** on it. Leaves occur at intervals. The space between two leaves is the **internode**. Each leaf has a narrow lower portion and a broad upper portion. The flat part of the leaf or **lamina** is deeply cut up at places. Some of the cuts may reach even up to the midrib. The leaves have no separate stalks. Examine carefully the angle between the leaf and the stem. What do you see ? There is a small bud with minute leaves. This is the **axillary bud**. Examine some older leaves. You may find that the axillary buds have grown into branches. Examine the tip of the shoot as well as the tips of the branches. You will see buds here also. These are the **terminal buds**.

At the tips of the branches or shoots you will find the **flowers** (Fig. 1. 2). Each flower has a stalk, the **pedicel**. The flower has several parts. The outermost are four small structures. These are green in colour. These are the **sepals**. Inner to the sepals are four yellow-coloured **petals**. Each petal has a long stalk-like portion and a broad region. Each petal appears to have a claw. Inner to the petals you will find six delicate filamentous structures. Each is a **stamen**. Of the six stamens two stamens are short while

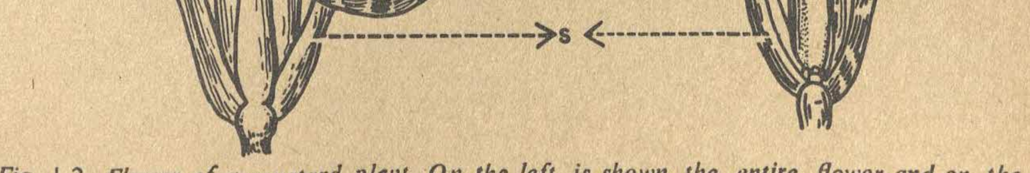

Fig. 1.2. Flower of a mustard plant. On the left is shown the entire flower and on the right a section of the flower showing the parts. P-Petals; St-Stamens : Pi-Pistil ; S-Sepal.

four are long. At the centre of the flower and inner to the stamens is an important structure. This is the **pistil**. It is cylindrical with a tip which is sticky. With a needle try to split open the pistil and see what is inside. You will notice some whitish structures. Now examine an older flower from which the sepals, petals and stamens have fallen and the fruit alone is left. Split open this fruit and examine the inside. What do you see ? You will see small green structures which are the **seeds**. Compare these structures with those which you have observed in the pistil. The structures in the pistil are immature seeds. Later on they develop into seeds. Examine still older fruits which are dry. See the seeds inside them. The dry fruits burst scattering the dark brown seeds.

The mustard plant is very useful to us. From the seeds oil is extracted and this oil is used in cooking. The seeds are also used for seasoning dishes.

§ 4. Forms of Plants

Plants have different forms of growth. They may be tall with a thick main stem and branches which bear leaves. Such plants are **trees**. The neem, banyan, mango and the palms are all trees. There are others whose stems are hard but they are not so thick and the plants are not so tall. They have a number of branches starting from the base of the stem close to the ground. The whole plant has a bushy appearance. Such plants are called **shrubs**.

There are still others which are small with soft stems. Most of the weeds and plants growing in shade and near water are **herbs**. The mustard plant whose parts you have studied is a herb.

Plants can also be grouped according to the length of the period they live. Some plants live only for one year, produce flowers and fruits and then die. Such plants are called **annuals**. Most flowering herbs in the garden, crop plants like paddy, mustard, are annuals. Most often the growth period is only for one season and not a complete year.

Biennials are plants which live for two seasons. In the first season they grow and store food and in the second season the food is used up in producing flowers and fruits. After this the plant dies. Biennials are common in countries with a cold climate. In tropics like our country many of these plants complete their life in one season. Such are radish, carrot and beet.

A large majority of plants live for many years. They produce flowers and fruits every year and continue to live. These are **perennials**. Plants like neem and oleander are perennials.

The Neem Tree

Neem is a very common tree in India. It grows in almost all parts of

Fig. 1.3. *The neem tree.*

our country. The neem is a tall graceful tree with dark-green foliage. It gives very good shade because of the dense cover of the leaves.

Neem is a fairly large tree and grows to a height of 12-13 metres (Fig. 1.3). It has a main stem, generally called the trunk. This is usually straight and bears branches only from a height of 3 metres from the ground. The branches give rise to many other branches, and along with the leaves the tree has a broad, round crown. The trunk is covered by a dark-brownish bark.

The leaves are green. Each leaf consists of a central stalk bearing on either side small leaflets with one leaflet at the terminal end. Each leaflet is long, narrow and pointed. It is slightly curved with the halves unequal. Its margins have toothed edges. The leaves are usually shed in February-March and new leaves are formed. The new leaves are reddish or purplish in colour and give the tree a beautiful appearance. In the hot southern part of the country new leaves appear at intervals throughout the year.

The tree bears flowers only during some part of the year. The flowers appear mostly during March and April. The flowers may appear a little earlier in the south of the country and a little later in northern India. The flowers are small, white and numerous, arranged in clusters (Fig. 1.4). They have a delicate smell or scent which you can notice when you walk under the trees.

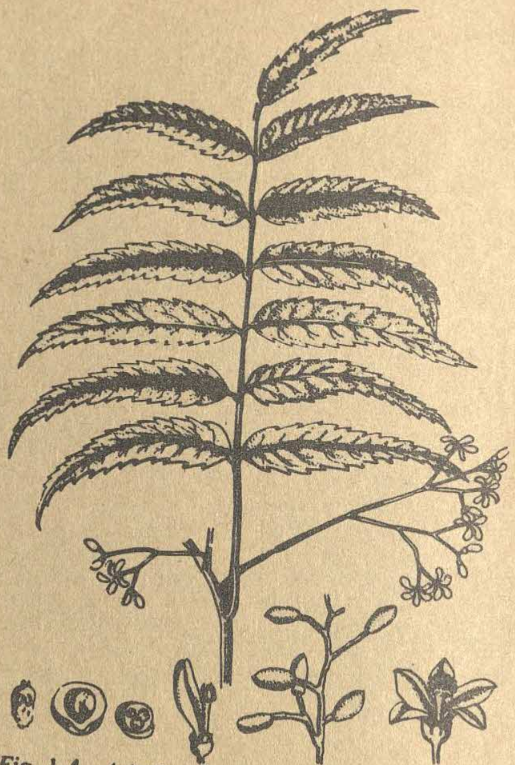

Fig. 1.4. A twig of neem tree with flowers and fruits.

The insects are attracted to the flowers. When the flowers drop off the flower shoot bears clusters of green fruits. When the unripe fruit is plucked from the tree, a white milky juice comes out. When ripe, these fruits turn yellow and you can watch birds picking these fruits and eating the fleshy part of them. Birds often eat the fruit and deposit the seeds far away from the original tree. Thus the seeds also get dispersed.

Uses of Neem Tree

The neem tree has many medicinal properties. Products from the tree are now used on a commercial scale in the manufacture of soap, tooth-paste, etc. Almost every part of the tree is useful medicinally.

You might have seen your elders bringing home a bunch of twigs. These green twigs are used to clean the teeth in the same way as tooth-brushes are used. The most important product of the neem is the oil extracted from the seeds. Some villagers use the oil to burn lamps. Mostly the oil is applied to the hair to keep off vermin and pests. But the smell of the oil is very bad. The dry leaves are put in between clothes and books to keep off insects. The leaves and twigs are used as cattle food and for manure.

Dry neem leaves are often boiled in water which is used for bath. The dry flowers are mixed in curries in some parts of the country.

The timber is hard and is used for construction of carts and agricultural implements. But the wood is mostly used as firewood. The neem tree is mostly grown for shade and as avenue trees.

The Jamun Tree

The jamun tree is large with dark green leaves. The tree is well known for its dark purple fruits which are eaten. It has a thick trunk and a heavy crown of leaves. The tree gives a good shade and so is used as avenue trees also.

The leaves are thick, smooth and shining. In the month of April or May the tree bears flowers which are small, white and occur in dense clusters. The stamens give the flowers a lace-like appearance. The fruits which are at first green become pink and then almost black when ripe. Each fruit has pulpy, fleshy outer part and a single seed.

The wood of the plant is used as fuel and for building purposes, carts and implements. The bark is said to have some medicinal value.

The tree is found in many parts of India and the fruits are liked by children and grown-ups.

Kaner (*Nerium indicum*)

Kaner is a large beautiful evergreen shrub. It does not grow more than 2–3 metres in height. There is no prominent stem but a large number of branches arises from the stem a little above the ground, thus giving the whole plant a bushy appearance. The stem is greyish in colour when old. The leaves are long, thick, linear and dark green in colour. They are arranged in whorls of three at the nodes. The plant bears flowers in clusters. Depending on the variety, the flowers are red, pink or white in colour. They are beautiful, showy and have a mild scent. The plant flowers almost throughout the year. The fruit is a narrow pod and has seeds with silky fibres.

The whole plant is poisonous. When you pluck the flower some sticky sap comes out. This plant has some medicinal use. The leaves boiled in oil are used as ointment in skin diseases. The paste made from the roots is used as cure for ringworm. Though the plant is poisonous yet it is prized by the gardener as an ornamental shrub for its beautiful fragrant flowers. It is sometimes used as hedge plant because the cattle and other grazing animals do not eat the leaves or parts of this plant.

Questions

1. How is neem tree useful to us?
2. How do you recognize a neem tree ?
3. What are shrubs and how do they differ from trees ?

Task

1. Collect neem leaves and flowers and make herbarium sheets of them.
2. Make a list of other useful trees in your locality.

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CHAPTER II

CELL : CELLULAR STRUCTURE OF PLANTS

We have studied the plant from outside. What is its structure inside ? How do we study the internal structure of a plant ? We cannot make out the details of the inner structure with our naked eyes. It simply appears as a compact mass. In order to see and study the internal structure of plants it is necessary to take sections of the part we want to study and examine them with the help of a lens or a microscope.

§ 1. The Lens

The lens is a magnifying device. Its main part is a magnifying glass. This glass is convex on both sides. Therefore, it is called a double convex lens.

The magnifying glass is held by a piece of metal and it has a handle (Fig. 2.1). The lens is held by the handle and carried nearer to the object till it is seen clearly. The lens gives only a small enlargement of this object to about 3-5 times. It is possible to mount the magnifying glass on a tripod stand. It is then called a mounted lens. Some lenses are more powerful and can enlarge the object 10-20 times.

Examination of Plant Structure Under a Lens

Take a thin piece of a ripe water-melon. Look at it first with the unaided eye. We can see small shining grains or ball-like structures. Let us place a thin piece or section of water-melon on a glass and examine it through the magnifying lens. Now we see more clearly that the real fleshy inner part of the water-melon consists of small rounded structures (Fig. 2.2). These are the **cells**.

If we examine thin pieces of apple or a tomato with a lens we can see that they also consist of cells. All these have cellular structures. Let us cut a section of an onion into small pieces. With a forceps lift off very carefully the thin transparent membrane from the inner surface of a piece of an onion scale. With the naked eye we cannot distinguish cells in the peel. The cells are too small to be seen. Mount this

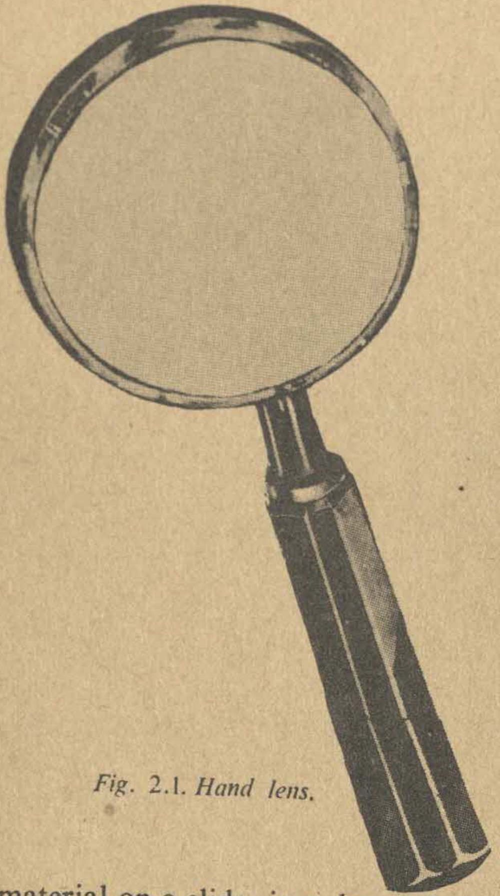

Fig. 2.1. Hand lens.

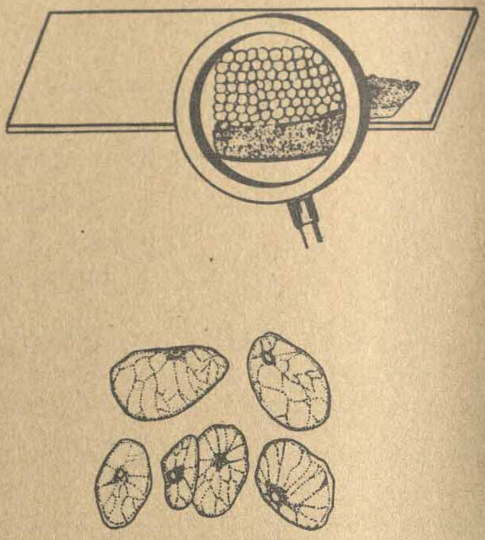

Fig. 2.2. Section of a melon fruit. A few cells magnified shown below.

material on a slide in a drop of water and place a cover glass over it and examine with a magnifying glass. We find small cells differing in size and shape from the cells of the water-melon. The cells are rectangular, more flat and long. The cells are set close to one another. We can conclude that an onion peel has also a cellular structure.

Most plant cells are very small. It is difficult to observe them only with the help of a lens. With the help of a microscope we can study cells better.

Questions

1. What do you see, when you examine a thin piece of a water-melon, apple or tomato under the lens ?
2. What does the inner part of a water-melon consist of ?
3. How are the cells arranged in an onion peel ?

Task

Examine a thin piece of an apple or tomato under a lens and draw figures of cells.

§ 2. The Microscope

The microscope is a complicated apparatus with a few magnifying lenses. Microscope is a Greek word with the meaning, *micro* small, and *scope* =to look. The word microscope signifies the device for examination of small objects. With a microscope it is possible to observe very small objects which is not possible either with the naked eye or with a lens.

The microscope magnifies an object up to 2000 times. If we observe a human hair under a microscope magnifying 200 times, it will look as thick as a pencil, the end of a pin will appear as a finger. Now, an electron microscope has been invented. The degree of magnification is very high being up to 200,000—300,000 times or even more.

The microscope consists of an optical tube, with magnifying glasses mounted at both ends (Fig. 2.3). At the upper part of the tube an eye-piece is fixed. An eye-piece contains two magnifying lenses. At the lower part of the tube an objective is fixed. It has a few magnifying glasses.

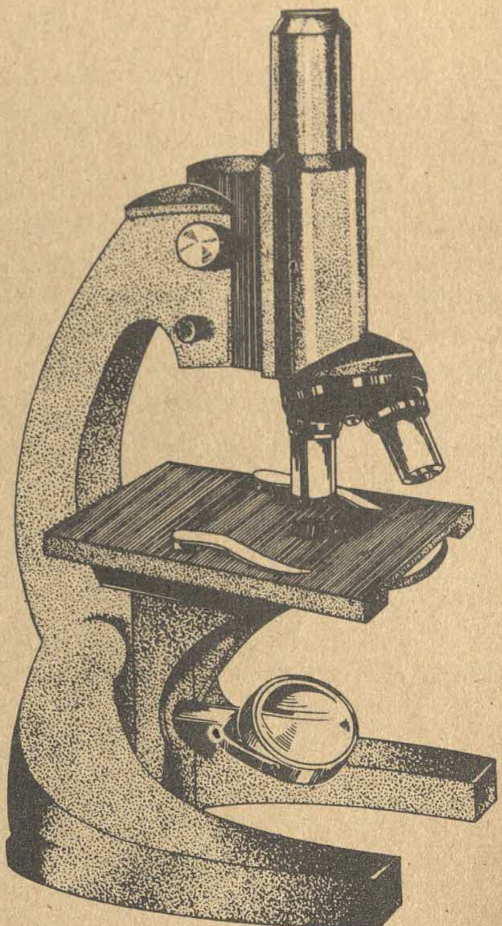

Fig. 2.3. Microscope

The optical tube is attached to a stand. The lower part of the stand is U-shaped and is called the foot. The middle part is called the arm. The optical tube can be raised or lowered by turning a coarse adjustment or fine adjustment screw. Under the objective there is a stage for keeping the objects to be examined. Below the stage is a movable mirror. The light falling on the mirror is reflected up through the hole in the stage to the object. The transparent object becomes visible. While looking through the eye-piece with one eye practise keeping the other open in order to avoid strain on one eye. An objective is brought down to the object which is to be examined.

Preparation of a Temporary Wet Mount

It is possible to examine under the microscope only very thin and transparent objects, which allow the light to pass through them. That is why in order to examine the inner structure of a plant it is necessary to prepare a mount out of it on a slide. It is very easy to prepare a wet mount of an onion peel from the inner surface of its scales (Fig. 2.4). Take a dry and clean slide. Wipe it with a piece of soft muslin cloth. Place on it 1-2 drops of water by means of a pipette or a glass rod. With the forceps lift off the thin membrane from the inner surface of an onion scale. Place it in the drop of water on the slide. With mounted needles arrange the peel in the water so that it has no folds. If the peel is stained in iodine we can better make out the structure. For this purpose add a drop of weak iodine solution to the drop of water on the slide and lower a cover slip over it. The cover slip should be dry above. Place the mounted slide on the stage and bring the peel just above the hole. Now adjust the mirror so that the specimen is well lighted. Very carefully and slowly lower or raise the optical tube by turning the coarse adjustment screw till you notice details on your slide. Now you can examine the peel magnified many times.

The microscope helps to discover many great secrets of nature. The inner structure of plants has been thoroughly studied with the help of a microscope.

Questions

1. What are the main parts of a microscope and how does it work ?
2. How many times does a microscope magnify an object ?
3. How do you prepare a temporary mount of an onion peel ?

§ 3. Structure of a Plant Cell

Examine the slide of an onion peel under the microscope. We see that the onion peel consists of many cells which are closely packed (Fig. 2. 5). The cells are rectangular, each having length, breadth and thickness. The cell has a thin transparent cell wall all around. It is possible to see the inner structures of the cell through the cell wall. Inside the cell, there is a jelly-like liquid called **protoplasm**. In the protoplasm there is a denser spherical body called the **nucleus**. The liquid outside the nucleus is the **cytoplasm**. If iodine solution is added to the slide, the cytoplasm will be coloured golden yellow and the nucleus dark brown.

In the cytoplasm we may find one

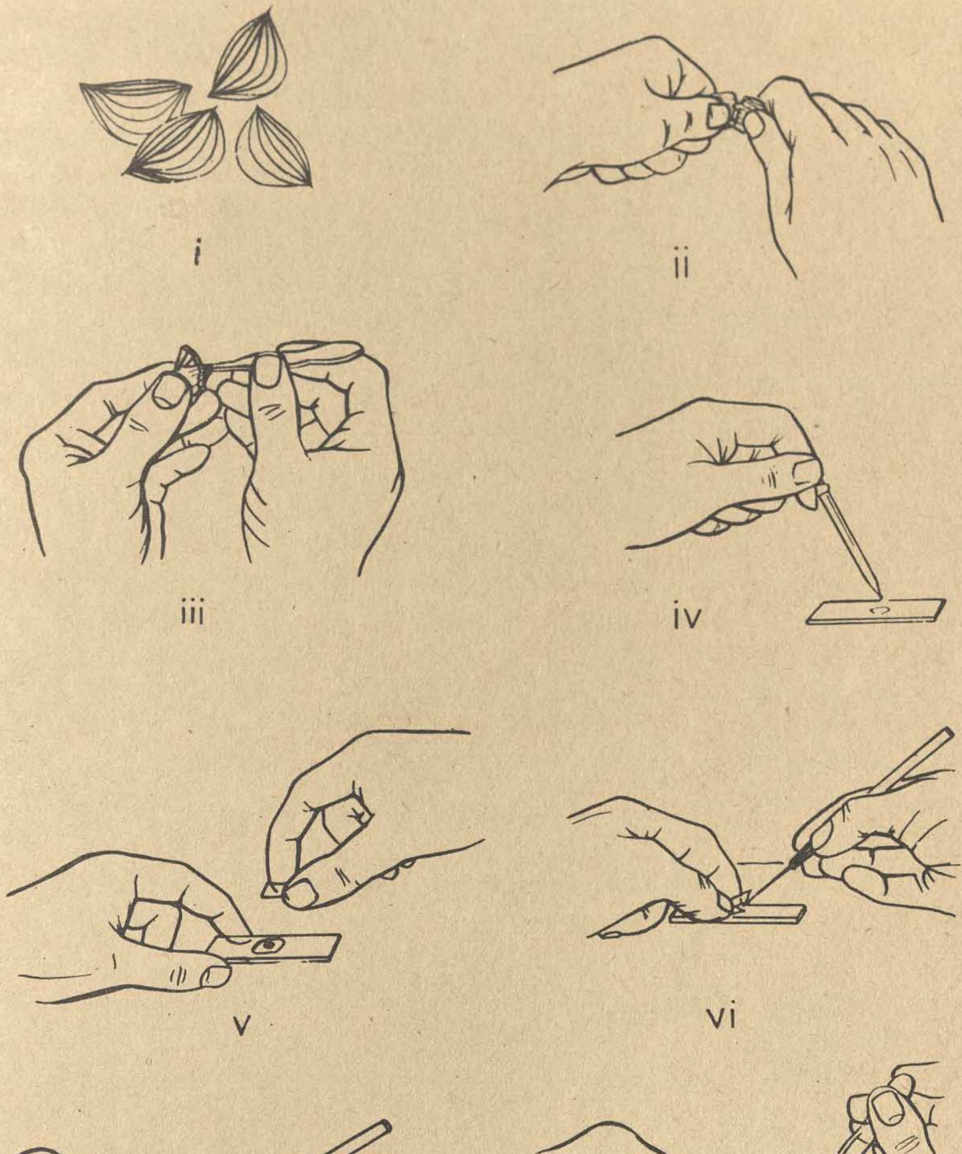

Fig. 2.4. Different stages in the preparation of a slide of onion peel.

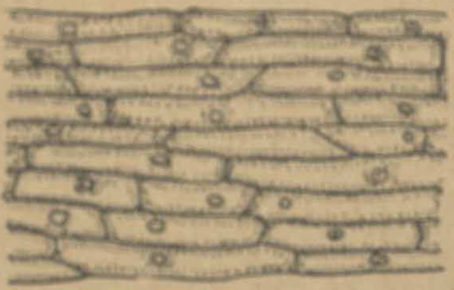

Fig. 2.5. Cell in the onion peel.

or more spaces filled with watery fluids. These spaces are called **vacuoles**. The fluid in the vacuoles is called **cell sap.** In some plant cells the vacuoles are in the middle of the cell and are so large that the bulk of protoplasm is pushed to a thin film next to the cell wall (Fig. 2.6). Sometimes the cell in a green leaf or a flower will have other tiny coloured bodies in the cytoplasm. These are **plastids**. Some plastids are coloured green as in leaves, sometimes they are yellow or red as in flower petals.

We notice in each cell : the cell wall, cytoplasm, nucleus, plastids, and vacuoles with cell sap.

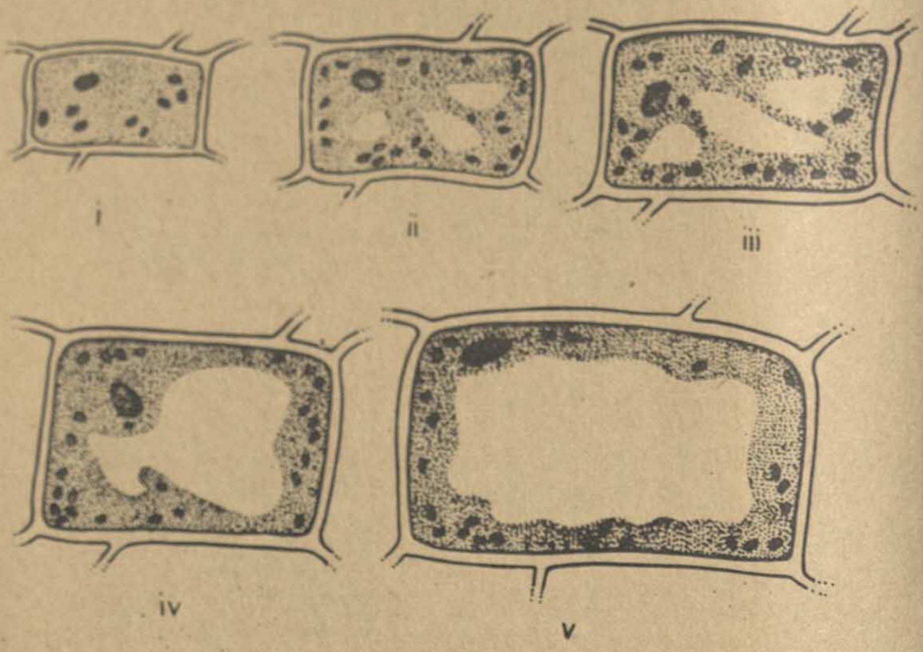

Fig. 2.6. Structure of cells from young cells to old ones.

Questions

1. What is the structure of a plant cell ?
2. What are the main parts of a cell ?

Task

Examine a cell from an onion peel, draw and name the parts.

§ 4. The Cellular Structure of Plants

With a sharp razor prepare thin sections of different plant organs (root, stem, leaf) and mount them in a drop of water. Afterwards examine them under the microscope. What do you see ? They all consist of cells. All plant organs have cellular structure.

Groups of cells which are similar to each other in form or which do the same work are called **tissues**. Each tissue will have its own characteristic features. Thus in a plant there are different types of tissues. All the tissues together form the plant organ or the plant body.

How does a plant which consists of cells form one living organism ? How are the cells held together ? They are closely packed and united to one another by means of intercellular substances. If we destroy this intercellular substance the cells can be separated. This will not take place in a living plant.

§ 5. Cell Division and Growth of Plants

How does a plant grow ? Scientists could explain this only after the discovery of cellular nature of plants.

Careful observations have shown that some cells are dividing. Each cell grows large and then divides into two cells. How does this take place ? When a cell has grown a little big, its nucleus divides. The division of the nucleus is a complicated process.

When the nucleus is about to divide minute thread-like structures appear in the nucleus. These are the **chromosomes**, and they have very important functions about which you will learn later. Each chromosome soon becomes double and moves to the centre of the cell (Fig. 2.7). Here all chromosomes lie in one plane. Very soon each member of the double chromosomes moves away to one end of the cell. There, each set forms a nucleus and thus two nuclei are formed from the original single nucleus. As the nucleus is thus dividing a wall is formed between the two daughter nuclei. The cell is divided into two by this cross wall. The whole contents of the cell is shared

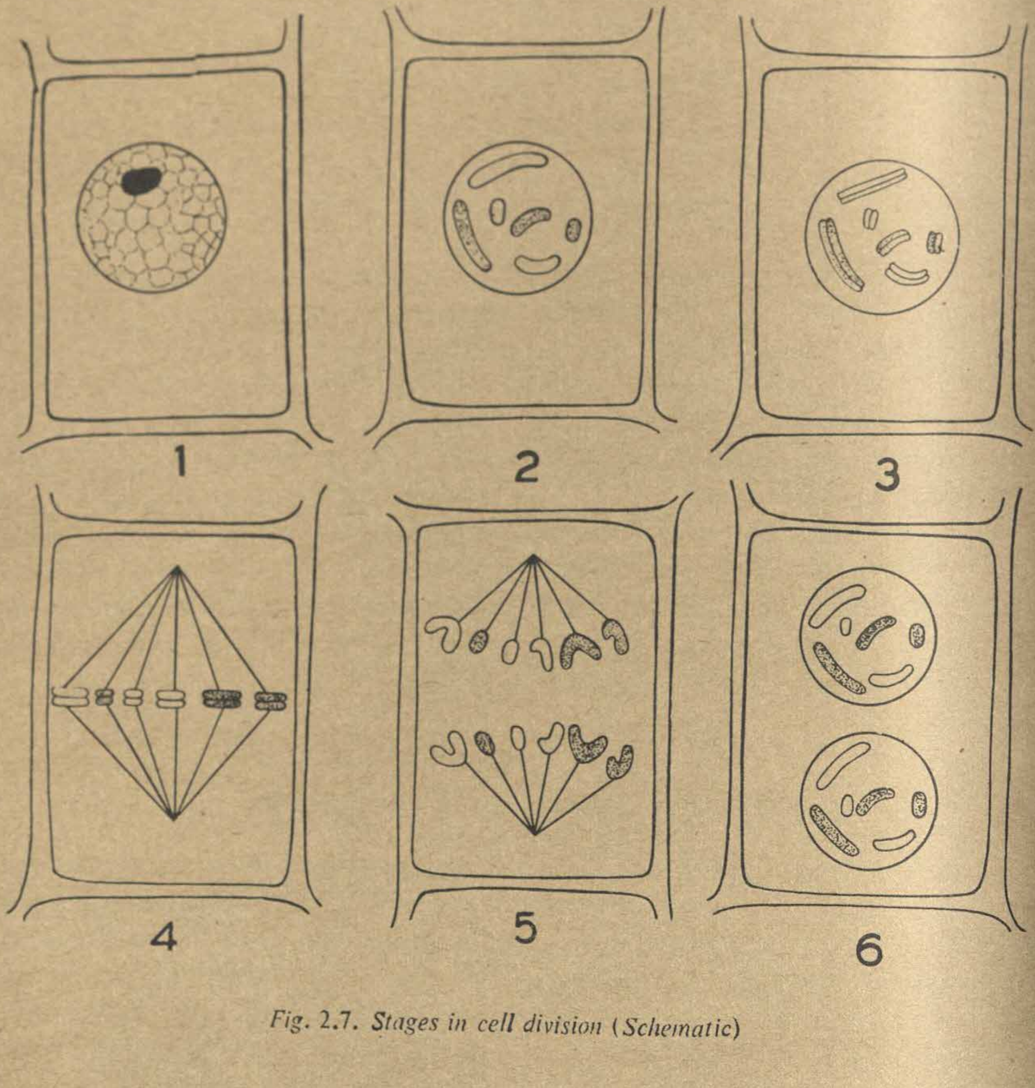

Fig. 2.7. Stages in cell division (Schematic)

between the two daughter cells. You will read more about this cell division in the higher classes.

When all cells in a group of cells divide, the number of cells increases. These cells in turn grow big and then divide. The number of cells progressively increases and the plant grows. Thus by cell division and growth not only the number of cells but also the shape and size of plant organs like leaf, stem and root change, and the whole plant changes.

Summary

Plants are made up of small units called cells. The cells are not visible to the unaided eye. These can be seen through a microscope. The plant cell has : (1) cytoplasm ; (2) nucleus; (3) plastids : (4) vacuoles with cell sap and (5) cell wall. These are the major constituents of a cell.

When a body has a number of cells, it is said to be cellular. Groups of cells are called tissues. They may perform the same function. The cells are held together by intercellular substance.

When a plant grows, the number of cells in it increases. This increase is brought about by cell division. Before a cell divides its nucleus divides. The nuclear division is a complicated process by which the number of chromosomes in it becomes double and each daughter nucleus receives the same number of chromosomes as the original nucleus. A wall is formed between the divided nucleus.

Questions

1. What do you see while examining the onion peel under the microscope?
2. How do cells divide ?
3. How does a plant grow ?

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CHAPTER III

THE SEED AND ITS GERMINATION

A dry seed does not germinate and it can remain like that for long without any changes. It appears to be lifeless and dead. It is said to be dormant. If the seed is given enough moisture and heat, it germinates. What is a seed? What is its structure? What are the necessary conditions for its germination? What is the best method to sow seeds in order to raise a better crop? Let us make a sudy of the seeds and try to get answers to these questions.

§ 1. The Structure of Bean Seed

The bean seed is rather big, and therefore it is possible to examine all its parts very well. The seed is covered on the outside by the seed coat. Depending on the variety, the seed coat may be white, light or dark brown, and it is generally smooth. On the seed coat there is a scar where it was attached to the wall of the fruit. The seed coat protects the delicate parts of the seed from drought and other unfavourable conditions. During germination the seed coat is broken. Inside the seed coat is an important structure which produces a new plant. This structure is called the **embryo**. It is possible to see an embryo on removing the seed coat from a bean

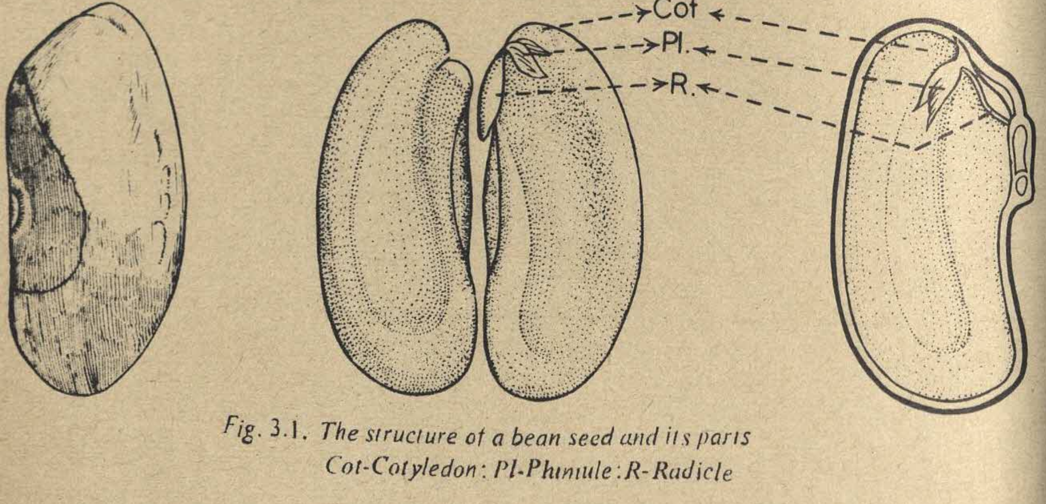

Fig. 3.1. The structure of a bean seed and its parts
Cot-Cotyledon: Pl-Plumule: R-Radicle

seed after soaking it in water overnight. First of all you see the large kidney-shaped cotyledons which are closely appressed to each other. If we pull them apart we can examine other organs of the embryo under the lens. These will be the future root or **radicle**, and the future shoot or **plumule** with a bud (Fig 3.1). An embryo cannot make its own food. It depends on the abundant food reserve stored in the cotyledons. The embryos of bean, pea and tamarind have two cotyledons. Such plants are called dicotyledonous plants.

§ 2. The Structure of Maize Seed

The maize grain is really a fruit In it the ovary wall is fused with the seed coat. The maize grains may be yellow, brown or even black. The grain is usually concave on the side on which the embryo is situated. If we cut the grain through the middle and examine the longitudinal section, we can see an embryo and a starchy mass which is called **endosperm** (Fig. 3.2). The endosperm forms the bulk of the maize grain. The nutrients are stored in the cells of the endosperm.

A lens is necessary to examine the maize embryo. It consists of a single cotyledon, a radicle and a plumule. The cotyledon is a broad flat structure lying against the endosperm

During germination its single cotyledon absorbs food material from the endosperm. The seeds of barley, wheat and rice have almost the same structure. Their seedlings have only one cotyledon. Such plants are called monocotyledonous plants.

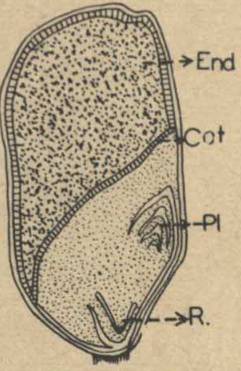

Fig. 3.2. The structure of a maize grain. End—Endosperm; Cot.—Cotyledon: Pl.—Plumule; R.—Radicle

Questions

1 What is the structure of a bean seed ?
2 What is the structure of a maize seed ?
3 What is common between the structure of a bean seed and that of maize
4 What is the difference between a bean seed and a maize seed?

Task

1. Examine a soaked bean seed and draw a figure. Carefully take out the seed coat. If the seed coat is not broken while soaking, break it with a mounted needle. After removing the seed coat examine the embryo. Find the two cotyledons, the radicle and the plumule. Draw the figure of an embryo and name the parts.
2. Examine dry,soaked and slightly germinated seeds of wheat or maize and draw figures. Find the endosperm and the embryo in a longitudinal section cut through the middle of the grain. Draw them and compare your drawings with the figures in the text book.
3. Compare the structure of the seeds of pea, maize, wheat and pumpkin. Soak the seeds and try to remove the seed coats. From which of the seeds is it easy to remove the seed coat ? Which of the plants given above are dicotyledons and which are monocotyledons ?

§ 3. The Composition of Seeds

Water. Even in apparently dry seeds there is water. If we heat dry seeds in a test tube over the weak flame or a spirit lamp, some droplets of water will settle on the inner walls of the test tube. The water present in seeds evaporates while heating and then settles as droplets on the cold walls of the test tube (Fig. 3.3). The seeds of different plants contain different quantities of water.

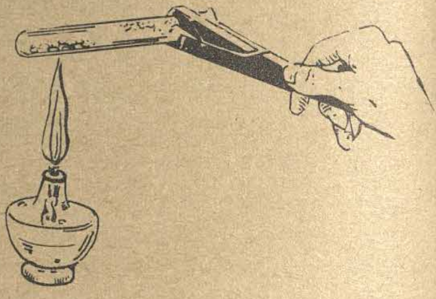

Fig. 3.3. Experiment to show the presence of water in seeds

Mineral substances. If we continue to heat the seeds they become brown and then black. Carbonization takes place. When they are set fire to they burn and only a very small quantity of ash is left behind (Fig. 3.4). The substance that gets burnt is organic. The ash contsists of mineral or inorganic substances which do not burn. This shows that seeds contain inorganic substances.

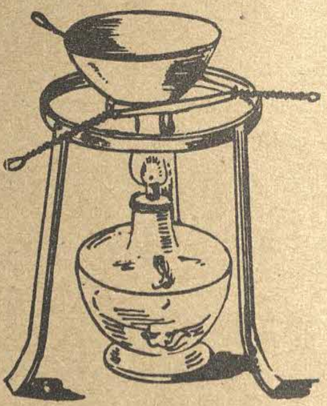

Fig. 3.4. Experiment to show the presence of mineral substances. in seeds

Organic substances. On grinding wheat we get the flour. On analysing the flour we come to know the food substances in the wheat grains.

Do this experiment. Prepare a small piece of wheat dough. Wrap it in a piece of muslin cloth. Immerse the bundle in a vessel of water and squeeze the bag and then mash it. The water becomes turbid (Fig. 3.5). Some pasty mass remains in the bag. Take some of the turbid water in a test tube and boil it carefully over the flame of a spirit lamp. When the water cools add a few drops of iodine to it and the liquid becomes blue thereby indicating the presence of starch. Test other starches like those of a potato or laundry starch in the same way. Take the paste out of the bag and place it on a glass plate and add iodine to it. If it does not turn blue, it contains no starch. It is protein and it can be compared with the white of an egg. It is a plant protein. Thus in the flour we discover two substances starch and protein.

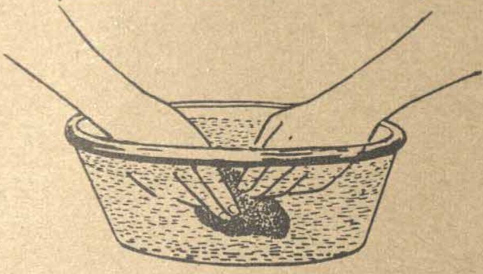

Fig. 3.5. Experiment to show the presence of organic substances

Some seeds will contain fat besides protein and starch. Take groundnut, or '*til*' seeds and scratch them on a piece of paper and observe the result. You will find some translucent streaks on the paper. These are the streaks of fat or oil.

Crush some groundnut seeds in a mortar. Place the powder in a test tube. Add some ether to the test tube and shake it. Let the solid contents settle at the bottom and pour the ether on a piece of paper. The droplets of oil indicate the presence of fat. The oil from these seeds and many others are used in cooking, making soap and in many other ways.

All these substances – starch, protein and fat – are found in the plant body. Therefore, they are called organic substances.

When the seeds are heated the organic substances are carbonised and then burnt. The ash left behind is inorganic.

Conclusion

In the seeds there are : (1) organic substances (starch, protein, fat) ; (2) inorganic substances, and (3) water. All these substances are necessary for the nourishment of the embryo.

The composition of seeds of different plants varies. For example, the seeds of Leguminosae (beans, peas and soyabean) have more protein. The seeds of cereals (wheat, maize) contain more starch. The oil seeds (groundnut, *til*, mustard) are rich in fats. If one presses oil seeds on a sheet of paper greasy spots will be left.

Questions

1. What are the organic substances present in wheat grains ?
2. How do the seeds of different plants differ in their composition ?
3. What do the seeds contain besides organic substances ?
4. How to you distinguish organic substances from the inorganic ones ?

Task

1 Find out the seeds of those plants which contain most (1) starch, (2) protein, (3) fat.

Name of plant	*Percentage of contents*					
	Water	*Protein*	*Fat*	*Starch and sugar*	*Other organic matters*	*Ashes*
Wheat	13.4	13.6	2.0	67.3	1.8	1.9
Maize	13.3	9.6	5.1	68.0	2.6	1.4
Pea	13.8	23.4	1.9	52.6	5.5	2.8
Soyabean	10.1	33.7	19.2	27.1	4.2	5.2

§ 4. The Composition of Air

We have discussed in the previous section the composition of the seed. Let us now study how the seeds give rise to a new plant. Everyone must have seen that when dry seeds are soaked in water and when there is plenty of air they germinate to become seedlings. Air seems to be very necessary for the germinating seeds. Before we learn about the germination of seeds let us know something about air and its composition.

Air is neccessary for Burning and Respiration

Air is transparent and colourless. Air is necessary for the burning of any material. Let us fix three lighted candles on a tray. Cover the first one with a small jam jar. The candle will be put out very soon. Cover the second candle with a bigger jam jar. The candle in this will burn longer but will go out soon. Do not cover the third candle. This will burn up to the last. (Fig. 3.6). The first jar has very little air and so the candle burns only for sometime ; in the second jar there is more air and the candle burns for a longer period ; the third candle having enough air burns out entirely. No burning is possible without air.

Air is necessary for breathing also. When too many people are present in a

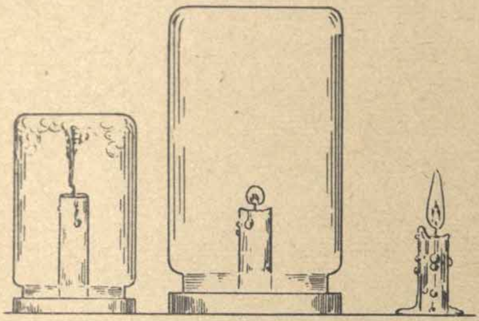

Fig. 3·6. *Experiment to show the necessity of air for burning*

small room it becomes difficult to breathe because of lack of pure air. It is necessary to ventilate the room to let the fresh air come in.

Composition of Air

Why is air so necessary for burning and respiration ? To be able to answer this question one should know the composition of air. Take a bottle without a bottom. Place this in a shallow dish containing limewater (slaked lime dissolved in water) and close the mouth with cork. The level of water inside the bottle will be the same as in the dish. The rest of the bottle contains air. Now take the bottle out of the dish and place a lighted candle stuck to a wooden block floating on lime water and replace the bottle over the candle and close it (Fig. 3.7). As the candle burns the level of lime water rises. The increase in the level of the lime water will correspond to 1/5 of the original volume of air in the bottle.

We notice that during the burning of the candle 1/5 of the air has been consumed. It was oxygen that was utilized in the burning of the candle. The lime water occupied the place of oxygen used up. The carbon dioxide, produced on burning of the candle, dissolved in the lime water. The gas that remained in the bottle was nitrogen. The candle could not burn in nitrogen.

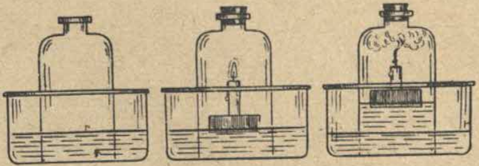

Fig. 3.7. *Experiment to show the composition of air*

Thus we see that air consists of a mixture of gases, namely, oxygen (1/5 of its volume) and nitrogen (4/5 of its volume). Besides these two gases the air also contains a little quantity of carbon dioxide and water.

Changes in Composition of Air During Breathing

Why is it difficult to breathe in a small room overcrowded with people ? Why is it necessary to have good ventilation in our appartments ? Fill a test tube with water and cover it with your thumb and invert the tube over a glass dish with water, so that the rim of the tube is below the water level. Through a rubber tube or a bent glass tube breathe out air into the test tube (Fig. 3.8). Take out the test tube with its mouth covered as before. Place a burning

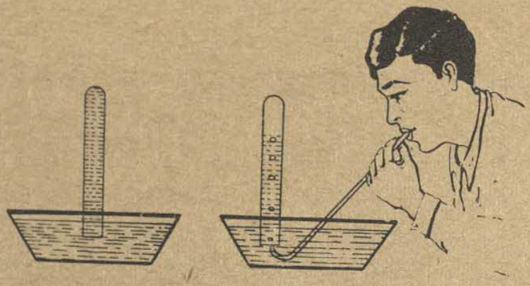

Fig. 3.8. Experiment to collect the exhaled (breathed out) air in a test tube

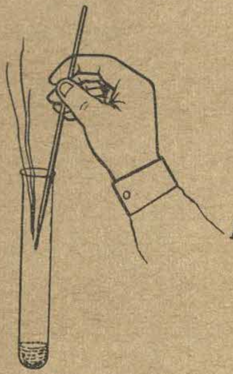

Fig. 3.9. Testing of exhaled air with the help of a burning splinter

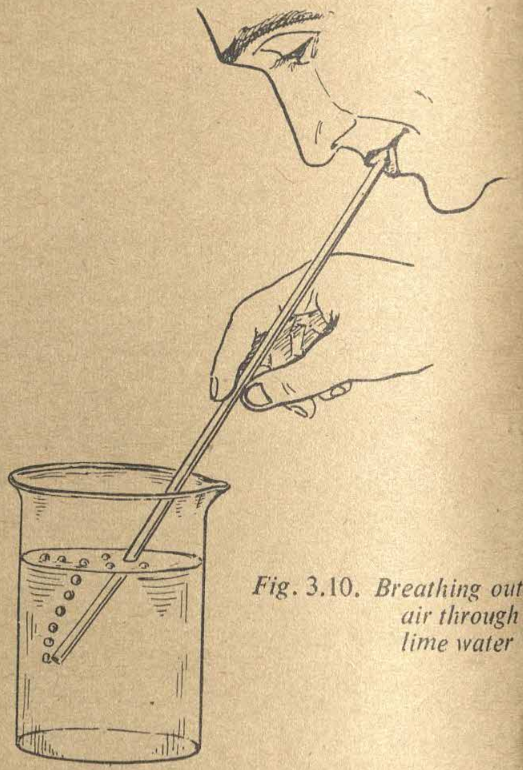

Fig. 3.10. Breathing out air through lime water

splinter into the test tube. This will be immediately put out (Fig. 3.9).

Let us try to breathe out air through lime water in a glass (Fig. 3. 10). It will soon become milky. This shows that air breathed out contains more carbon dioxide. When people breathe in an ill-ventilated hall, the composition of air changes : the quantity of oxygen decreases while that of carbon dioxide increases. In such a hall people will find it difficult to breathe. Thus we find that oxygen is necessary for breathing.

§ 5. Conditions Necessary for Seed Germination

Dry seeds can be kept for a long time in a granary almost without any change. When they are sown, they germinate and shoots arise. What are the conditions necessary for their germination ?

For germination of seeds three conditions are necessary : (1) supply of water, (2) air and (3) suitable temperature. If one of these conditions is absent the seeds will not germinate. That is why while ploughing the field the seeds are placed in moist loosened soil which has a proper temperature.

Role of Water

Let us take two glass tumblers and put 10 pea seeds in each. Leave the first glass as such and let it remain dry. Pour some water or put a piece of wet cotton wool into the second one. Cover both the tumblers with glass plates and set them aside in a warm place. After 3-4 days we see that the dry seeds in the second glass have germinated. Thus it is found that water is necessary for seed germination.

The seeds absorb water and swell, and as a result of swelling the seed coat is broken. We see inside an embryo. An embryo can utilize food only in the liquid state. Water is necessary to convert food reserves in seed into a liquid form.

Different plants require different quantities of water for germination. The seeds of leguminous plants need much water. Therefore, their seeds are soaked before sowing.

Role of Air

Let us take again two glass tumblers and put 10 pea seeds in each. Pour water into the first glass to half its height. The seeds are completely covered and do not get plenty of air. Pour a little water or place a piece of wet cotton wool in the second one. After a few days the seeds in the first tumbler will swell but not germinate. They have enough water but not enough air. Air is necessary for the seeds to germinate. The seeds in the second tumbler have sufficient quantity of water and air to germinate. Thus it is found that air is necessary for seed germination.

Only the seeds of swamp plants and rice can germinate under water. The small quantity of air dissolved in the water is enough for their germination.

Role of Heat

A suitable warmth is necessary for seeds to germinate. Different plants have their own requirements of heat. The seeds of such cereals as wheat begin germinating at low temperature (1-2°C). The maize seeds germinate at higher temperature (10-12°C), and the seeds of cucumbers and pumpkins at 12°C. The seeds of plants having their origin in tropics germinate at a higher temperature. Cucumbers are native to India and pumpkins and maize are from Central and South America where the climate is also hot. The seeds of southern plants require higher temperature to germinate.

Questions

1. What are the conditions necessary for germination of seeds ?
2. Which seeds require more water for germination ?

Task

1 Take 20 dry bean seeds or 30 pea seeds and weigh them. Soak the seeds in water. Next day wipe the seeds with a dry cloth or blotting paper to remove excess of water and weigh the seeds again. Is there an increase in the weight of the seeds ? Why do they increase in weight ?

2 Repeat the experiment with 50 grames of wheat and 36 grames of maize.

§ 6. Respiration of Seeds

Let us find out if the seeds respire or not. For this purpose take two gas jars. Put some germinating pea seeds into the first jar and cork it tightly. Put this in a warm dark place. In the second jar no seeds are put but it is also plugged and put in the same place (Fig. 3.11). After two days remove the cork in each jar and introduce a burning splinter into each of them. The splinter introduced in the first jar will be put out while that introduced into the second jar will keep on burning. It means that the composition of the air has changed in the first jar. The quantity of oxygen is reduced and the quantity of carbon dioxide has increased. Thus germinating seeds have consumed oxygen.

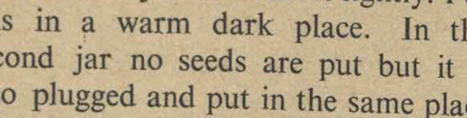

Fig 3.11. Soaked seeds give out carbon dioxide during respiration

In order to prove this let us put germinating seeds into a bottle plugged with a two-holed cork. Insert a funnel through one hole and a twice bent glass tube in the other (Fig. 3.12). Now place the bottle in a warm dark place.

After a day test the air in the bottle. Lower the end of the glass tube into a test tube filled with some clear lime water and then pour water through the funnel into the bottle. The air in the bottle gets replaced into the test tube containing the lime water. The latter becomes

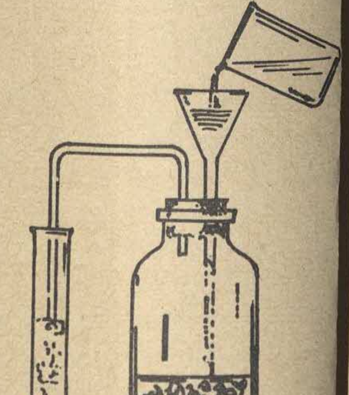

Fig.3.12. Carbon dioxide given out during respiration of seeds turns lime water milky

nilky indicating the presence of carbon lioxide. Thus germinating seeds while espiring give out carbon dioxide. When erminating seeds respire they take in xygen and give out carbon dioxide

Now it is clear that for seeds to erminate air is necessary. It is not erminating seeds only that respire, but lry seeds also respire. But their respiraion is very low. It is difficult even o notice.

All living organisms like man, animals and plants respire all through their life during day and night. There is no life without respiration. During respiration all organisms consume oxygen and give out carbon dioxide.

Production of Heat by Seedlings During Respiration

If we fill a jar with germinating seeds which are slightly damp with water and place a thermometer there (the jar should be covered with paper, cotton or some insulating material), in some hours a rise in temperature will be noticed. It takes place because the germinating seeds produce heat during respiration. At the same time the food material stored in the seeds are used up.

§ 7. Germination of Seeds

The mature seed usually does not germinate immediately but remains dormant for some time. Under favourable conditions the seed germinates to produce a new plant. These conditions include a supply of water, oxygen and a suitable temperature. The seed swells by absorption of water. The embryo begins to respire intensely, take food and grow. The radicle starts to elongate and emerge from the seed and then the plumule appears. Thus the embryo becomes a seedling.

Food for the Seedling

From the very beginning of its growth the seedling utilizes the reserve food stored in the seed. The main mass of organic matter stored in a seed is starch. But starch does not dissolve in water and therefore it cannot be used by the embryo during germination. How does an embryo use this reserve food substance ? Germinating seeds of wheat or maize are sweet to taste. The taste of dry seeds is quite different and they are not sweet. It is known that starch stored in cotyledons or endosperm is transformed into sugar during germination of seed.

It is possible to prove this by an experiment. Take half a teaspoon full of some laundry or potato starch, make a paste of it and pour some water and stir. Boil it and let the paste cool. Add a few drops of iodine solution to it and pour into a petri dish or a plate.

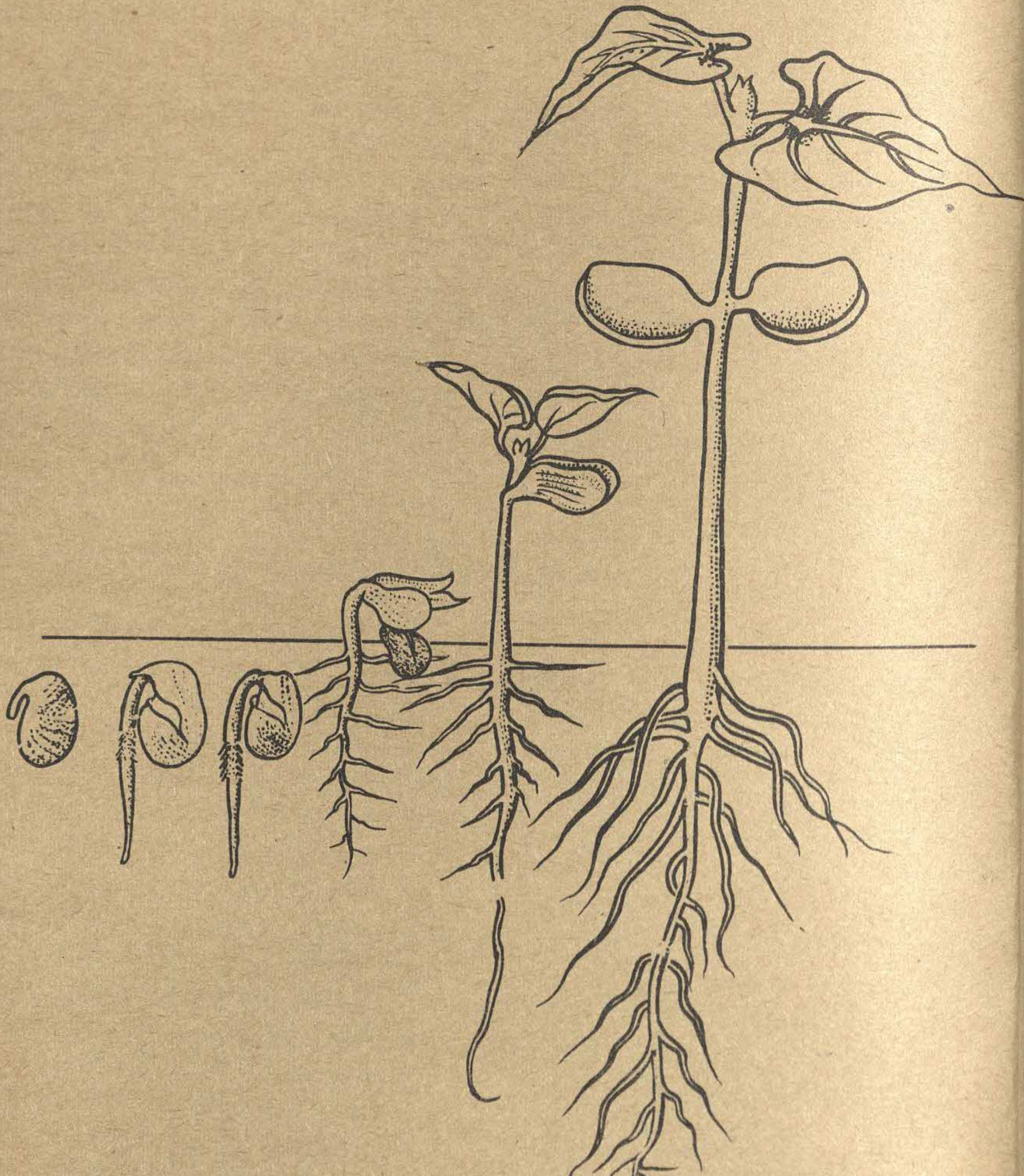

Fig. 3.13. Germination of a bean seed

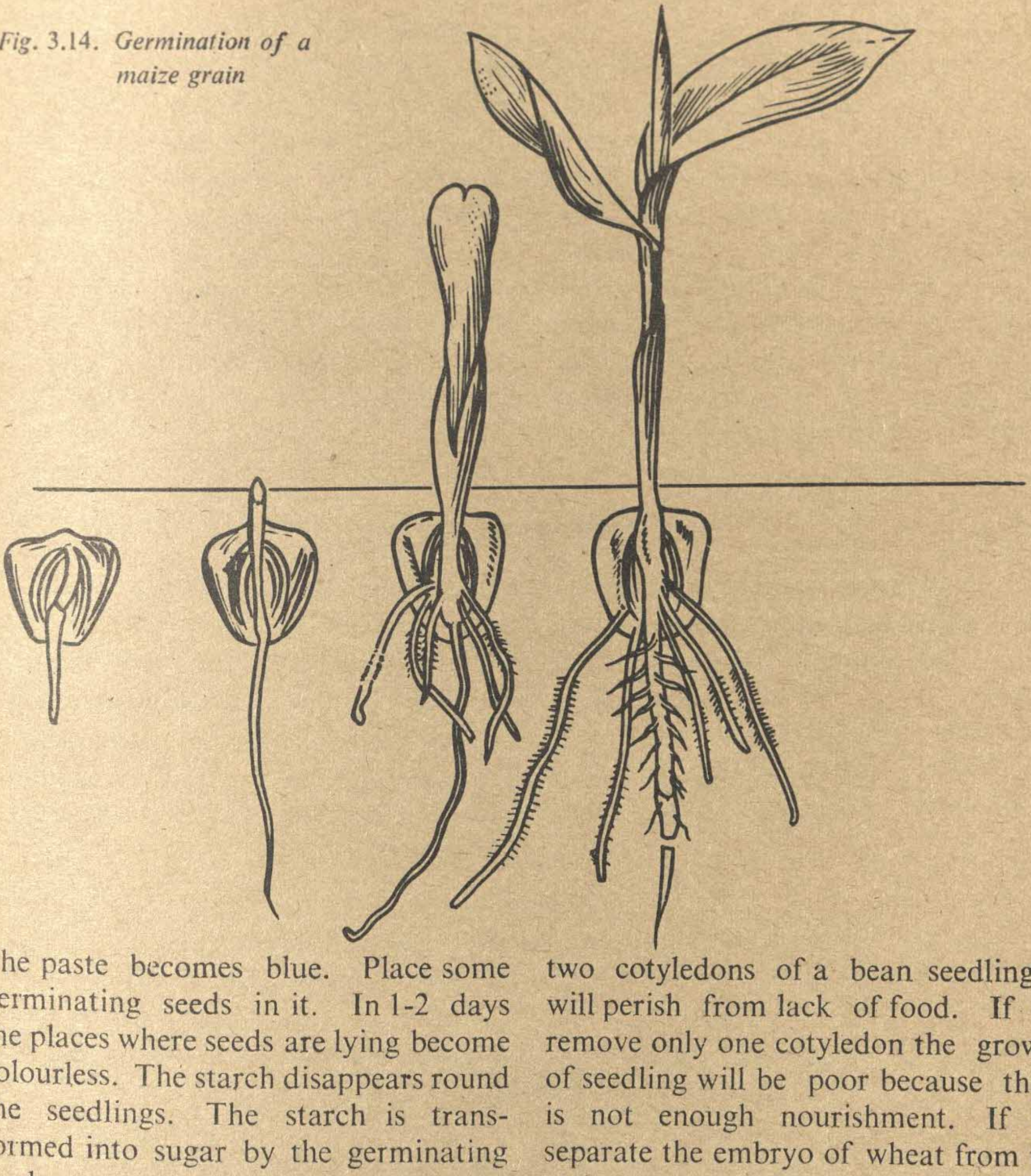

Fig. 3.14. Germination of a maize grain

The paste becomes blue. Place some germinating seeds in it. In 1-2 days the places where seeds are lying become colourless. The starch disappears round the seedlings. The starch is transformed into sugar by the germinating seeds.

The seeds of bean, pea, pumpkin and other dicotyledonous plants have abundant reserve food stored in the cotyledons. The seeds of maize, wheat and majority of monocotyledonous plants have the reserve food material in the endosperm. If we remove the two cotyledons of a bean seedling it will perish from lack of food. If we remove only one cotyledon the growth of seedling will be poor because there is not enough nourishment. If we separate the embryo of wheat from the endosperm and place the seed in the soil it will also perish. If we remove only a part of the seed, the seedling can survive but it will be very weak.

While the bean seedling is growing the reserve food is gradually utilized. The wheat seedling uses the food material in the seed outside its cotyledon.

Appearance of Shoots

On germination of seeds of bean, wheat or any other plant, the radicle appears first. It grows into a root which soon branches. The roots begin to absorb water and dissolved mineral substances from the soil. Similarly the plumule continues to elongate and forms the stem and leaves. The actively growing shoots appear above the soil. From this time the new plant begins to prepare its own food.

Monocotyledonous plants hav only one cotyledon. But this does no come out of the seed. The radicle emerges first and is immediately followed b the first leaf. The growing plumule i covered from the very beginning with cap-like structure. It preserves th delicate tip of the plumule and its lea from damage while growing through the soil. Then the leaves break through it.

Summary

In a dormant seed there is an embryo. Food material is stored in the seeds. The embryo develops into a seedling. From the very beginning an embryo uses these organic and inorganic matters stored in the seed. An embryo and a seedling are alive and they respire as every living organism does.

The germination of seed requires three conditions : supply of water, oxygen and a suitable temperature. Different plants require different amounts of water, oxygen and heat.

Questions

1 How do seedlings get food ? Where is the food substance stored in the bean, pea and pumpkin seeds ? Where are they stored in wheat and maize seeds ?

2 Compare the seedling of monocotyledonous plant with that of dicotyledonous one ? How do they differ from each other ?

Task

1 Observe the germination of pea seeds. For this purpose sow 15 pea seeds in a box with soil. Every two days take one seed or seedling and examine it and draw figures. Note the date above each drawing when the seed or seedling is taken and examined. Take them and prepare herbarium specimens.

2 Repeat the same observation for the germination of maize or wheat seeds.

CHAPTER IV

THE ROOT : ABSORPTION OF NUTRIENTS FROM THE SOIL

The first part of the embryo to come out of a germinating seed is the radicle. The radicle becomes the root of the seedling. At first the seedling obtains food materials from the cotyledons. But the cotyledons fall off after sometime. From this time the seedling depends upon the soil for its raw materials. The roots obtain the raw materials and and water from the soil. This is one of the main functions of the roots. The other main function of the root is to fix the plant firmly in the soil. There is still another function of the roots. In some plants the roots store food materials in them.

We have said that the roots absorb the nutrients from the soil. What is soil ? Let us read about it in the next few pages.

§ 1 Soil and Its Composition

Soil is the upper layer covering most part of the earth's crust. This is loose and soft. It supports plant life.

What is the Soil Made of ?

Take a gas jar and pour some rain water which has been previously collected in clean glass vessels and stored. Put into it a handful of soil from the garden. Stir it well with a glass rod and allow it to settle down. Observe carefully how the various constituents of the soil settle down to form one layer above the other (Fig. 4.1). You will find a layer of large particles at

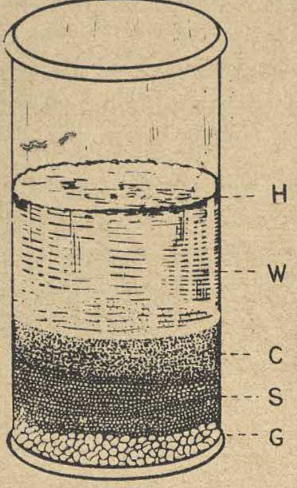

Fig. 4.1. Different layers of soil : H-humus; W-water; C-clay; S-sand; G-gravel

the bottom. This is gravel. Above this will be a layer of sand. The layer above the sand will be of clay. Over all these layers stands the column of water which is turbid. Floating on the water are light particles of decaying vegetable and animal matter. This floating part of the soil is called humus or organic matter.

Let us see what the turbid water contains. Carefully tilt the jar and pour the water into a flask without disturbing the sediment. Filter the water through filter paper fitted into a funnel. By filtration the minute particles of clay are removed. Pour the filtered water in a china dish and evaporate it over the flame of a spirit lamp. What do you observe in the china dish after the water has evaporated ? There is a crust of salts left behind.

Let us evaporate only rain water in another dish and see what is left behind. After evaporation no salts will be found in the dish. This experiment shows that rain water has no salts dissolved in it. The salts left behind in the earlier experiment were present in the soil. These were dissolved by the rain water that was added to it.

The soil holds some water in it. Take some soil and put it in a test tube. Heat it over the flame of a spirit lamp as shown in (Fig. 4.2). After sometime you will find droplets of water on the test tube. The water in soil is not perfectly pure water. There are many different salts dissolved in it. By salts we do not mean only common salt. There are other mineral salts in the solution.

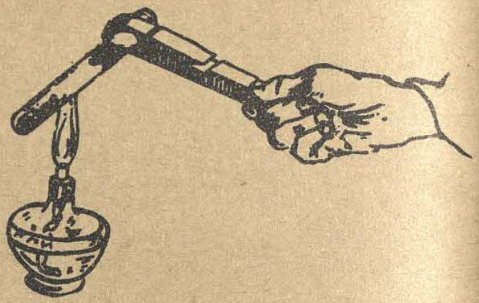

Fig. 4.2. Experiment to show the presence of water in soil

You can find out the importance of these mineral salts to the plants if you do the following experiment.

Take a beaker and put some garden soil into it. Add rain water and stir it. Allow it to settle down for sometime. Take the liquid part and filter it. Take two bottles with narrow mouths. Into one pour rain water. Into other pour the soil extract. Select two grown up seedlings of identical size. Fix the plants in the bottles in such a way that their roots are in the liquid and their stems and leaves are in the air (Fig. 4.3). Use cotton to hold the plants at the necks.

You will find that the seedling in the bottle with only rain water is not growing so fast as the other one, and after some time it will die off. From this experiment, it can be inferred that it is not the soil which is necessary to the plants, but certain salts in solution present in the soil that are very important.

The presence of water in the soil is important for the life of plants. The

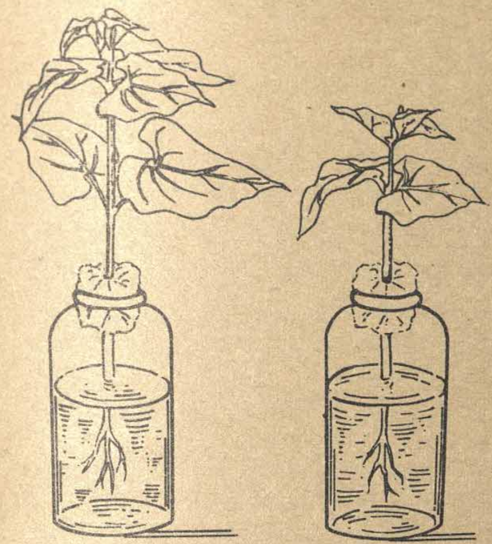

Fig. 4.3. Importance of mineral salts for the growth of the plant. The bottle at left contains soilextract and the bottle at the right contains rain water

soil is made up of minute particles. These particles are very irregular in shape. Therefore, even when they are closely packed there is still some space left in between the particles. Soil water is usually present as a thin film surrounding the particles. The rest of the soil is occupied by air.

The presence of air in the soil can be demonstrated by means of a simple experiment. Take some loose soil into a glass tumbler to half of its capacity. Slowly pour water over the soil until the glass is almost full. You will find small bubbles of air coming out of the soil. Why does this happen? The water gets into spaces occupied by the air. The air thus displaced comes out as small bubbles.

How do these tiny soil particles get surrounded by thin film of water during the dry summer months ? Water is available inside the earth far below the layer of the top soil. How does the water reach the upper layers of the soil ? The experiment described below will give the answer. Assemble an apparatus as shown in the Fig. 4.4. It consists of a horizontal rod to which are tied several vertical glass tubes with bores of different diameters. Dip these tubes into a trough containing coloured water. Observe the level of water in the different tubes. You will see that narrower the tube greater is the height to which water will rise. In earth the particles of soil form millions of narrow capillary tubes. In every narrow tube the water rises due to capillary force. The same force operates with regard to the soil particles also.

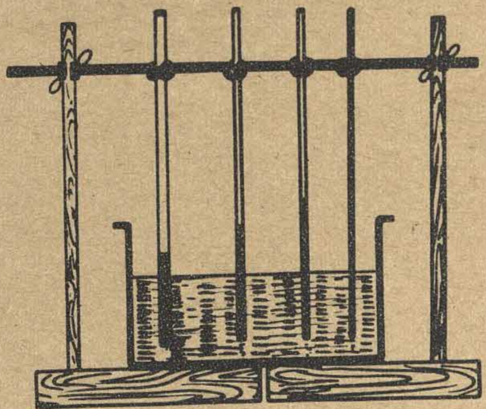

Fig. 4.4. Rising of water in capillary tubes

We have examined the nature of soil. The soils found in different areas are not the same. There are many kinds of soils. What makes the soil look different ? It is the size of the grains or particles that compose it and the proportions in which these particles are present. Most soils consist of a good mixture of gravel, sand, clay and humus. Such soils are called loamy soils. A soil is said to be sandy if it contains more than 50 per cent of it as sand. It is clayey if clay constitutes 50 per cent of it, and so also with regard to gravel.

A loamy soil is the best soil for growing plants. It is easy to plough. It holds enough of soluble mineral matter, water and air necessary for plant life. It also contains humus. Humus helps to keep the soil as lumps. In this way more air is held between the lumps.

Questions

1. What are the main constituents of soil ?
2. Which type of soil is best suited for growth of plants ? Why ?
3. How will you prove that soil contains moisture ?

Task

Collect samples of soils from garden, a river-side and a dried up lake bed. Perform experiments to separate the constituents by sedimentation. Find out which of them has more sand; which more clay. Which of these will support the growth of plants well ?

§ 2. Types of Roots

When you dig out a plant for studying its parts, you would notice that the roots are well spread in the soil. They are also in close contact with the soil. When you pluck a plant, you see lumps of soil adhering to the roots. This close contact enables the plants to absorb water and nutrients from the soil. Let us study whether all the roots are similar or different.

The bean plant, banyan tree and others have a tap root. The tap root is the main root. From the main root a number of smaller branches arise at the sides. These smaller roots penetrate the soil in all directions. Take any plant and study its tap root system.

Find out the difference between this type of root and that found in plants like maize, wheat, paddy, grass and palms. The main root is absent in these plants and instead a bunch of small roots are found to arise from the base of the stem. This type of root system is called the fibrous root system.

Compare the development of these two types of roots in young seedlings. Take some bean seeds and some corn seeds and put them in two flower pots containing moist soil. Let the seeds germinate into seedlings. Dig out one seedling of each type and observe the roots. Note that both seedlings began their life with a main root. After sometime the main root in the corn seedling does not grow further. Instead a number of roots arise from the base of the shoot. In the bean seedling the main root continues to grow and gives off a number of smaller lateral roots.

In marshy regions, the soil is clayey and contains excess of water. There is very little air in the soil. In order to get air the roots send out finger-like upright branches. These processes have a large number of pores through which the roots exchange gases with the air. Such roots are called breathing roots.

The banyan is a large and spreading tree. From some branches a large number of rope-like structures hang down. These are aerial roots. They hang down, and when they strike ground they develop normal roots which spread in the soil. These pillar-like roots help to give support to the heavy branches. The screw pine sends down oblique roots from the stem. These

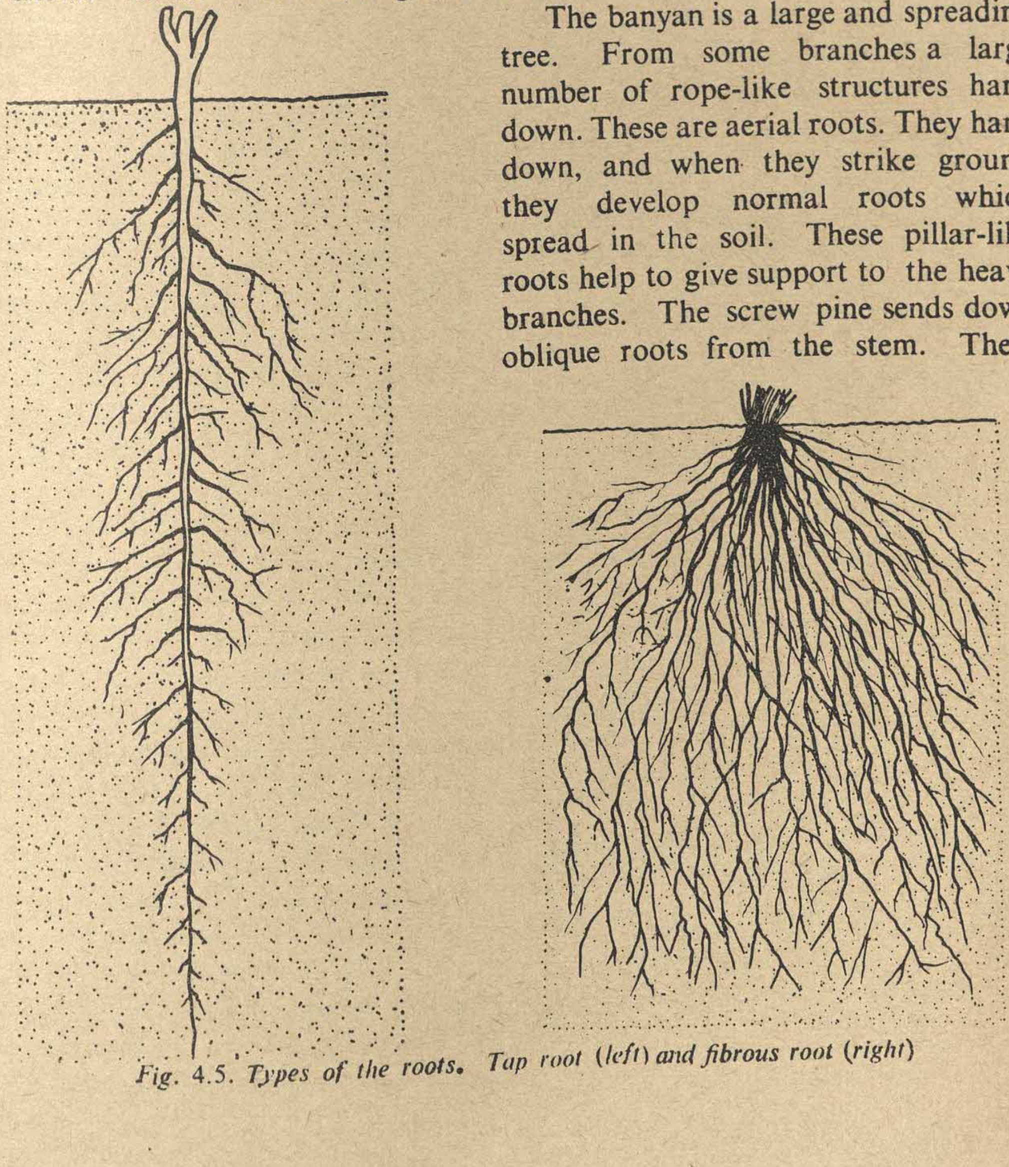

Fig. 4.5. Types of the roots. Tap root (left) and fibrous root (right)

roots support the weight of the heavy branches. Thus in the banyan and the screw pine these roots are called prop roots. In some plants roots also do the work of storing food material. The radish, beetroot and carrot are roots which are swollen. The swelling is due to accumulation of food material.

§ 3. Parts of Roots

Let us now examine the different parts of roots. We have already seen that the main roots give rise to lateral roots. These in turn produce more branch roots. Trace a branch root to its tip. Examine its tip carefully with a lens (Fig. 4.6). You will find that the tip is covered by a thin cap-like structure. This is called the root cap. The tip grows in the soil penetrating in between the soil particles. The tip is a delicate structure. It might be damaged by the rough surface of the soil particles. Therefore, the root-tip is protected by the root cap.

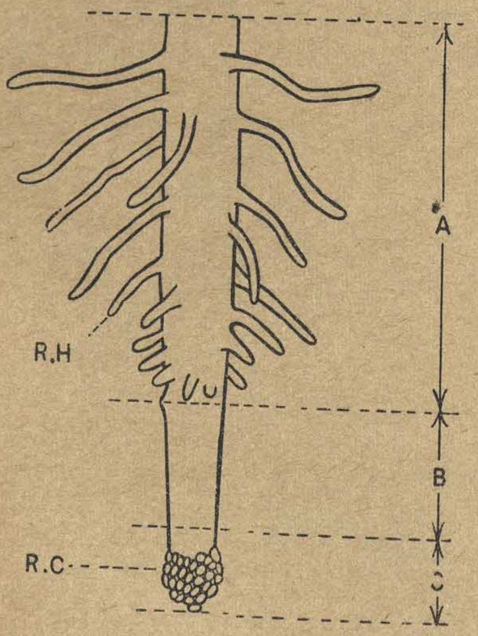

Fig. 4.6. Magnified view of the root tip to show different zones of growth. (R.H.-Root hair; R.C.-Root cap; A-zone of root hair B-zone of elongation; C-Zone of root tip covered with root cap).

Examine the portion of the root behind the tip. There is at first a clear region. Behind this region is a portion covered with fuzz-like outgrowths. These are root hairs. It is the region that absorbs water and mineral salts from the soil.

The root hairs can be seen well by performing the following experiment. Take some seeds of *methi* or mustard seeds. Leave them on moist blotting paper at the bottom of a saucer. Cover it with another saucer in such a way as to allow exchange of air. Take care to see that the blotting paper remains always moist. After a day or two you will find that the seeds have germinated and have produced roots. Examine the fuzzy growth with a magnifying lens. The root hairs are clearly seen as delicate hair-like structures.

The region between the tip of the root and the root hairs is the growing region of the root. It is called the **zone of elongation.** Maximum growth takes place in this zone. It can be demonstrated by the following simple experiment.

Place some bean or pea seeds soaked in water on moist cotton in a dish. Keep the cotton and watch the seeds. The root first comes out as a slender cylindrical structure. With Indian ink draw lines at equal intervals of 2 mm on the root. Allow the root to grow for a couple of days. Then examine whether the marks are equidistant or whether some intervals are longer than the others (Fig.4.7). You will note that the intervals between the divisions behind the tip of the root have become longer. This indicates that more growth has taken place in the zone of elongation.

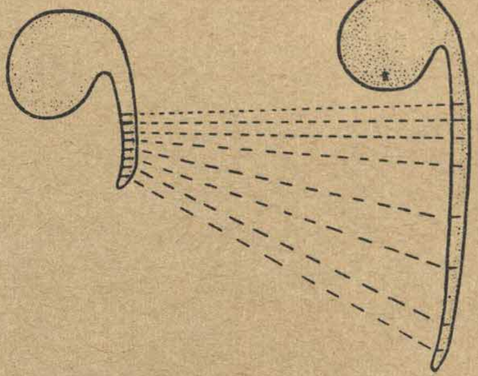

Fig. 4.7. Experiment to show the zone of elongation

Where water is found only near the surface of the soil the roots spread only in the top layer. Farmers have the practice of cutting off the mainroot to encourage the growth of lateral roots. These lateral roots spread in the region where water is in plenty. Thus the plants get more water and nutrients.

Questions

1. What type of roots do grasses have ?
2. Which part of the root grows in length ? Describe an experiment to verify this.
3. What is a root hair ?

Task

Collect the tap roots of any small plant and the fibrous roots of grass and make herbarium sheets of them.

§ 4. Internal Structure of Root

Take a thin cross section of a young root of bean plant in the region of the root hairs. Place the section in a drop of safranin stain. Lower a cover glass carefully over the section and draw out the excess of water with a blotting paper. Now examine the section under the microscope. You will see that the roots are made up of cells (Fig. 4.8).

There is an outermost layer of cells.

This layer protects the other cells lying below. This layer is called the **epidermis**. Some of the cells of this layer are extended into minute projections. These are the **root hairs**. Internal to the epidermis is a region of large-celled tissue. These cells have plenty of air spaces between them. This is called the **cortex**.

Inner to the cortex are found some cells which are different in structure. In the centre there are thick-walled cells (stained red) with four angular projections. The projections point towards the outside of the root. These cells form the **xylem.** These thick-walled cells serve to conduct water up the roots. In between the two xylem projections are

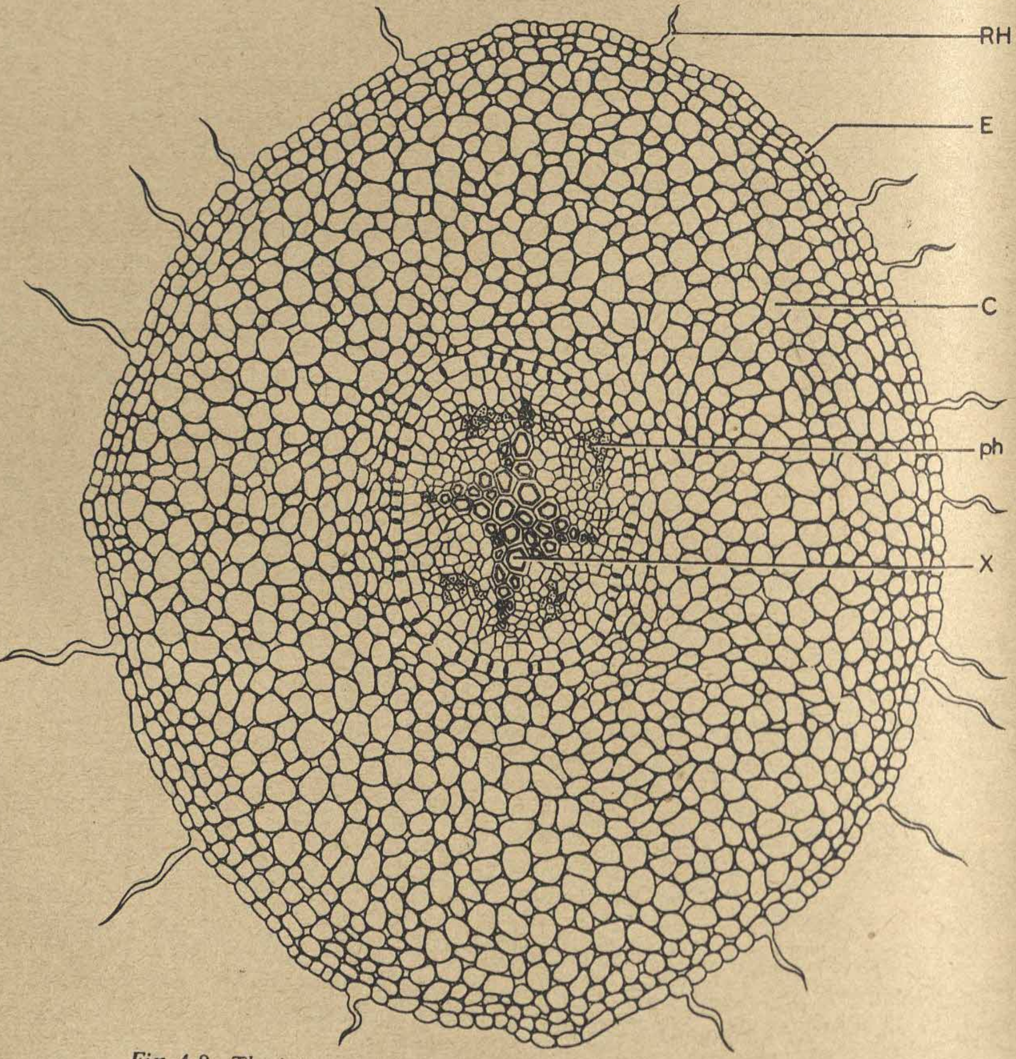

Fig. 4.8. The internal structure of a young root of bean: R-Root hair; E-Epidermis; C-Cortex; X-Xylem; Ph-Phloem

some cells with thin walls. Their contents look darker. These are the **phloem cells.** They conduct food material to different parts. The xylem and phloem together form the **vascular tissues**. The xylem cells in older roots also give strength to it.

§ 5. Absorption of Water and Nutrients

Plants are living things. For their activities they need food. The plants are capable of preparing their own food out of raw materials like water and mineral salts in solution which are absorbed by the roots.

Arrange two test tubes, one containing water in which the roots of a small plant such as a bean seedling are dipping. Keep the plant in position by cotton wool. Cover the water with a thin layer of oil to prevent any evaporation. The second tube is arranged in exactly the same manner but without the plant. Mark the levels of water in the tubes with a strip of paper. Leave the tubes in a warm, dry place for a day. It will be seen that the tube containing the plant has lost water, while that without a plant has not. It can be inferred from this experiment that plants absorb water through their roots.

Can a plant absorb solids ? To find out this, set up two tubes as before but each containing a plant. Colour the water of one tube with eosin solution. Add a pinch of carmine to the other tube. Carmine will also make the water look red, but it does not dissolve. The red colour is due to minute solid particles of carmine which are so small that they remain suspended in water. After a while we can observe the fall in the water level of both the tubes. The plant dipped in eosin is tinged with red and that dipped in carmine is not. This suggests that a plant is unable to absorb solids such as carmine. It can only absorb solutions. The raw materials needed for the plants are absorbed as solutions.

Perform this experiment to find out how roots absorb water and nutrients from the soil. Take a carrot which has a large top. With a knife scoop out a cavity at the top of the carrot to a depth 2-3 cm. Fill this cavity with concentrated sugar solution (Fig. 4.9). Insert tightly a one-holed cork through which a glass tube is passing at the top. Place the carrot in a jar of water for a few hours. Note the initial level of sugar solution in the tube. Note the level again after a few hours. Observe the rise in the level of sugar solution. The rise in level is due to the water absorbed from outside by the root.

We have already seen that all water and mineral food from soil enter the

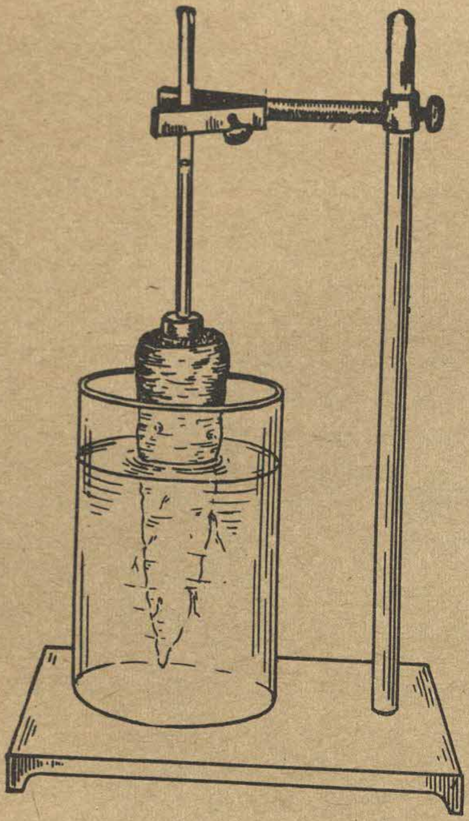

Fig. 4.9. An experiment to show that water is absorbed through the root

plant through the root hairs. These materials pass through the membrane of the root hairs. The solution thus absorbed has to be taken to the leaves where food is manufactured, so that these materials are used. The long cells through which water is carried up are situated in the central region of the root. How does the solution absorbed by the cells reach the central vessels? The solution from the smaller roots enter the main roots. Then they are conducted to the leaves through the stem.

A wheat plant looks weak but it is not blown over by wind. There is something that keeps the plant firmly fixed to the soil. Before a heavy wind the plant simply bends in the direction of the wind. Even a big tree withstands ordinary storms. What makes these trees firmly fixed to the soil ? Their roots anchor the plant firmly in the soil. The roots penetrate the soil in all directions. That is why when you pull out a plant, it comes out with a large amount of soil attached to its roots. The amount of roots that usually comes away is only a small fraction of the total amount. You will be surprised to know that the roots of the wheat plant usually penetrate to a depth of one and a half metres or more. The roots of trees often cover as much space underground as the branches and leaves do above the ground.

The roots in certain cases also perform another function. The tap root gets swollen with food material. Radish, carrot and beet-root are examples.

§ 6. Irrigation

The plants need water. The nutrients from the soil are absorbed by the roots only in the form of solutions. Thus if there is not enough water in the soil, the plant suffers. Water is also used by plants in the making of its food and also in various other life activities. Supply of water is very important in the cultivation of useful crops, fruit trees, etc. The supply of water to cultivated plants is called **irrigation**.

Irrigation may be such a simple process as watering the lawns and garden plants. It may be a complicated process in which water is stored in a reservoir by means of dams and taken out through a system of canals. One way to increase irrigation is to dig wells, utilize water in the ponds, lakes and rivers. By these means, the crops or cultivated plants can be supplied with water at a time when they need it most. These methods will increase the yields of cultivated plants. The building of dams and reservoirs conserves rain water which otherwise would be drained away into the sea.

§ 7. Fertilizers

When a crop is grown in a particular soil, it takes up mineral matter from it for its growth. If we grow crop after crop in the same plot, after a few seasons the soil becomes poorer in the mineral nutrients. The succeeding crops will yield less and less. A wise farmer adds something to the soil to replace the minerals used up by an earlier crop. This something is called **fertilizer.** A fertilizer may be organic or inorganic (chemical) in nature.

By adding organic and chemical fetilizers the soil can be enriched. Any matter derived from the remains of dead plant or animal body is called organic fertilizer. The addition of these increases the nutrient content of the soil and thus crops in such soils give good yields to the farmer. Some examples of organic fertilizers are compost manure, green leaves, oil cakes, cowdung, etc. The chemical fertilizers very often used are ammonium sulphate, super phosphate, potassium chloride, potassium sulphate, etc. Good use of these fetrilizers will improve the return from the crops. If farmers practice enriching the soil, the amount of food produced by the country will increase.

If a farmer grows the same kind of crop year after year in a soil, the crop takes out the same kind of materials and the soil becomes poorer in that material. But a different kind of crop may take different materials. Thus by alternately growing one crop during one season and another in another season, the soil does not become impoverished in the same kind of mineral.

The farmers will get better yields, if they grow wheat in one year, *bajra* in another year and some other crop in the third year. Growing any crop of *dal* increases the fertility of the soil. Pull out a *dal* plant and examine its roots. Do you find small swellings ? These are called **nodules**. The nodules contain bacteria inside them. These bacteria are capable of using nitrogen from the air and converting it into useful nutrients. These nutrients remain in the soil and they are used by the next year's crop. Plants cannot use nitrogen present in the atmosphere directly. This practice of growing different crops in different seasons is called **crop rotation**. Wise farmers rotate corps in their field to get better yields and also to enrich their soil.

§ 8. Preparation of Soil

Before you grow a crop in the field or plants in the garden, the soil must be prepared well. Ploughing the soil in the field and digging of earth in the garden loosens the soil and the young plants grown in them get enough air.

After ploughing, the soil is harrowed or raked. In this, large chunks of earth are broken into smaller pieces. This leaves the soil loose. It helps to conserve the water supply in the soil.

Uses

Many roots such as radish, carrot and beet are used as vegetables. Sweet potato and tapioca which are full of food material are eaten. Starch is obtained from tapioca. This starch is also used in the preparation of sago. In some western countries sugar is obtained from one variety of beet-root. *Khus khus* which is used in screens during summer is the root of a particular plant. The roots of some plants are rused as medicine in the Ayurvedic system.

Summary

The roots are the underground parts of a plant. They serve to absorb water and nutrients and also fix a plant firmly in the soil. Some roots store food also.

The roots are intimately connected with the soil. The soil is usually composed of gravel, sand, clay and humus. It has also water which rises to the surface through capillary force, in the space between soil particles. The soil has also air in the spaces between the particles.

Many plants have a main tap root and in others fibrous roots are developed in the place of tap roots. In some, roots are modified to do other functions. The tip of a root is protected by a root cap and the region of elongation is just behind the tip. After this comes the region of root hairs.

The vascular tissues are in the centre and these help in conducting water and mineral salts to the shoot and in conducting prepared food where it is needed.

In order to get better yield from the plants the farmer adopts some practices. One such practice is good irrigation by which a good supply of water is maintained. The soil is prepared well. Rotation of crops is adopted to enrich the soil; organic manures and chemical fertilizers are also used to enrich the soil or to make good the useful material taken away from the soil by the previous crop.

Questions

1. In which part of the root is water transported ?
2. How are roots important to a plant ?
3. What steps would you take to improve a soil poor in mineral nutrients?

Task

Visit a park when the gardener is preparing a flower bed. How does he prepare the soil ? Note down the things he mixes up.

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CHAPTER V

STEM : TRANSPORT OF SUBSTANCES IN THE PLANT

You have examined various parts of a germinating seed. You have also watched what happens to these parts as the seed develops into the seedling. The plumule of the seed develops into the young shoot. As the seedling grows further, the young shoot differentiates into the main stem, branches and leaves.

The stem is a very conspicuous part of a plant. Let us learn about the main functions of the stem. We learnt in the previous lessons that the root hairs absorb water and mineral substances from the soil. You will study in the next chapter that these substances are utilized by the leaves in manufacturing food materials out of them. These substances must first be transported to the leaves from the roots. The stem helps to conduct these substances from roots to leaves.

The food is prepared by the leaves. All parts of the plants need them. Sometimes food is stored in certain parts of the plant. Therefore food prepared in the leaves has to be transported to different parts. This is done through the stem.

You must have noticed that the stem is the thickest part of the plant. This is because it has to bear the weight of the branches which bear the leaves, flowers and fruits. By serving as a support to the branches, it enables the leaves to be exposed to sunlight and air in the best possible way for preparing food materials. You will learn that sunlight and air are essential for the leaves to manufacture food.

Food manufactured by the plants is utilized by them for different activities and for growth. Plants do not always utilize all the food materials. Some amount of food is saved and stored up in the plant itself. Different parts in different plants serve as the storage organs. Have you ever tasted sugarcane juice ? How do we get sugar? Sugar is prepared out of the juice extracted from sugarcane. In sugarcane the food is stored up in the stem.

§ 1. Development of Stem

Examine the young shoot of a fairly grown up seedling. Watch the changes that take place during the growth of the seedling into a mature plant. Observe the differences between the stem of a well-grown plant with that of a seedling. In course of time the leaves at the base of the seedling fall off. These places are marked by scars on the stem. What other differences are there between the young shoot and the shoot of a fully grown plant? You will notice that a grown up plant has many branches. Let us see how these branches develop.

BUDS. Examine the tip of a young seedling. Do you see a bulb-like structure ? This is called the **terminal bud**. The bud consists of the young stem with a number of very young and delicate leaves crowded together. Wait and see what happens to the bud. As days pass on, the stem of the bud elongates and the leayes unfold. The growing point remains young all the time. It continuously adds length to the stem and a number of leaves.

Cut the head of a cabbage plant. Observe the different parts. There is a central axis round which leaves are tightly packed (Fig. 5.1). The cabbage is an example of a large bud. Normally, buds are small. Examine the bud of a banyan tree. With a needle remove the scales carefully. Below you will find tiny delicate leaves (Fig. 5. 2). You will see that the bud is really a shortened stem on which the tiny leaves are closely packed. The bud in banyan is called a **scaly bud**. The scales of buds protect the tender, young leaves.

Examine carefully the base of the leaf-stalk where it is attached to the stem. The angle between the stem and the leaf is called the **axil**. You will notice a bud in the axil also. The buds present in the axils are called **axillary buds**. In size these buds are very minute. These develop into lateral branches.

The buds described above are vegetative buds because they develop into vegetative shoots. There is another kind of bud. These develop into flowers. They are, therefore, called flower buds. Note the position of the flower buds. They are usually found at the tips of the leafy shoots.

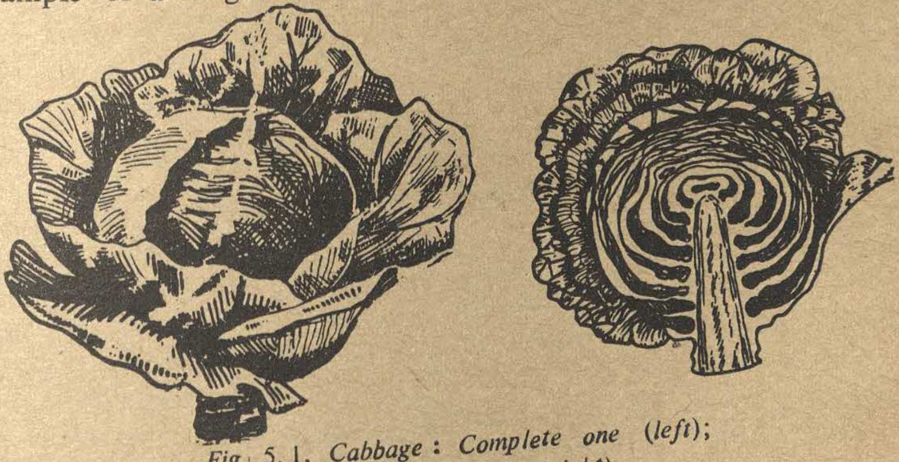

Fig. 5. 1. Cabbage : Complete one (left); longitudinal section (right)

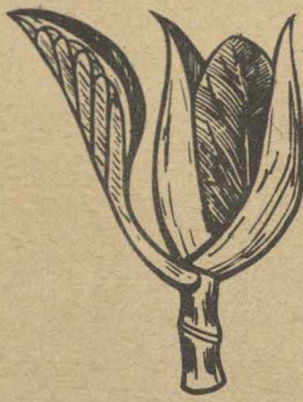

Fig. 5.2. Bud of banyan tree

The plant has buds on it in all seasons. Some buds grow into shoots. But during certain seasons, for example after the first rains, the buds show increased activity. They all grow more rapidly and the plant shows new shoots in plenty.

GROWTH REGIONS OF STEM. You have studied the elongation of the roots. Let us see what region of the stem grows more. Select a young seedling of a pea or bean. Mark the shoot end into equal divisions, 3 mm apart. After two or three days, note the divisions (Fig. 5. 3). Are they equidistant? Find out which portion has elongated more than the others. It is this portion that has shown the greatest growth. The maximum growth is mainly at the upper part of the shoot.

TYPES OF STEM. Stems vary in size, form and structure. In length they may vary from less than a centimetre to more than 150 metres. The stem is soft in a herb and hard in a shrub. In palm tree, it is cylindrical and unbranched. Many trees show branching.

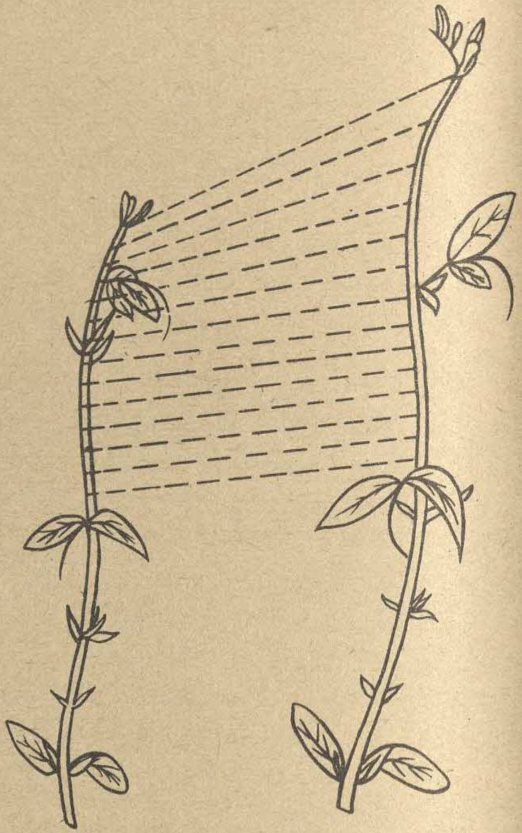

Fig. 5.3. Expeirment to show the growth zones of stem

In one type of branching, the main trunk is thick at the base and tapering towards the top. Branches are given off from this trunk which spread horizontally. The lowest branches are longest and are the oldest. The upper branches are shorter and younger. The whole plant has a conical form. The pine tree while young has a conical shape. Other trees of this type are the *Casuarina* and the garden variety of Ashok. In the second type of tree, the main trunk is erect and branchless for some length from the ground and later it gives off a few branches which in

Fig. 5.4. *Forms of trees*

turn bear secondary branches and so on (Fig. 5.4). The branches and the foliage together form a broad round crown. Such trees are the banyan, neem and tamarind.

Some trees like the *gul mohur* grow quickly. But there are others in which the growth is slow (banyan and neem). Next time you visit a park or botanical garden, look out for plants with labels announcing the person who planted the tree and the date on which it was planted. Note the dates of planting and compare the different growths in different trees. Ask your teacher and the gardener and make a list of different kinds of quick-growing and slow-growing trees. The tallest tree in the world is the *Sequoia*, the redwood tree which grows in California. A fully grown tree will be as much as 100 metres high and several hundred years old.

A plant has many axillary buds. In fact there are as many axillary buds as there are leaves. All of them do not develop into branches. They remain dormant. If the terminal bud is cut off, the axillary buds below it develop. Cutting off of the terminal bud can be practised, if we want a number of branches. In some parts of the country men cut off green shoots to use them as manure in their fields. The cut plants soon produce a number of lateral shoots.

In tea plantations the workers pluck the young bud and two leaves from tips of branches. This pinching off stimulates the tea plant to produce more shoots from axillary buds below. Thus the tea plant gets a bushy growth.

§ 2. Diversity of Stems

In many plants the stems grow erect. They may be soft as in herbs or hard as in shrubs or trees. The former types are called **herbaceous stems** and the latter **woody stems**. These stems stand erect and support the branches. In some plants the stem is weak and cannot stand erect without support. Such weak stems either grow horizontally on soil or they twine around stronger supports or other stems. Still others cling or attach themselves to other trees or supports by means of various structures.

There are two main types of weak-stemmed plants that grow on the ground.

PROSTRATE. Examples of this type are cucumber, watermelon and pumpkin. The stems lie prostrate on the ground and grow horizontally. Some weeds also grow horizontally.

CREEPERS. These resemble the prostrate plants. The stems lie horizontally on the ground. They differ from them in striking roots at each node (Fig. 5.5). You can lift the whole shoot of the prostrate type because it is free and not attached. You cannot lift the whole shoot of the creeper because the shoot is fixed to the soil at various places.

Weak-stemmed plants, which make use of supports for their growth, are climbing plants. There are two main types of climbing plants.

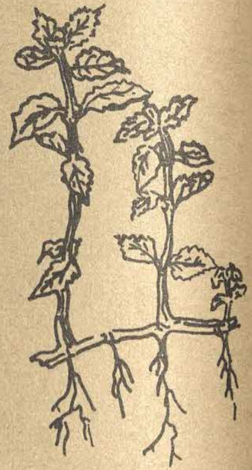
*Fig.*5.5. *Creeper* (*mint*)

TWINERS. Many of you might have grown bean plants in your kitchen garden. You must have provided some support. Did you examine their stems? They have slender stems with long internodes. They coil round the support and climb (Fig. 5.6). Watch the tender tip of the plant twining around any support with which it comes in contact.

CLIMBERS. The climbers too need support for their growth. But stems of these plants are not capable of twining around objects. How do these plants climb? There are different structures that help them to cling to the support (Fig. 5.7). Many of you

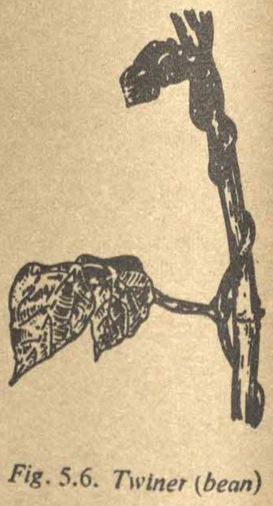
Fig. 5.6. *Twiner* (*bean*)

must have seen the pea plants. Did you see certain wiry structures at the tips of the branches? These are called **tendrils**. Observe how they are coiled round the supports. In certain plants there may be small curved hook-like structures. These help the plants to climb up. Thus these plants reach great heights to expose their leaves to light.

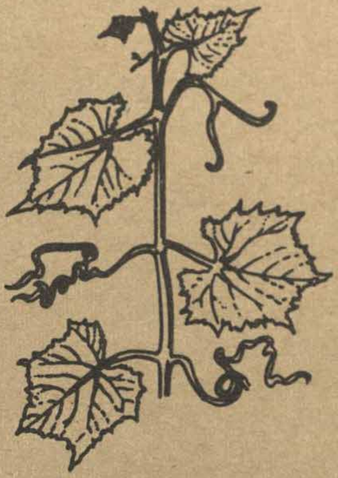

Fig. 5.7. Climber (grape)

§ 3. Effect of Light on Growth of Stem

We have seen in the earlier section that the climbers reach great heights in order to expose their leaves to the best light available. Why do plants appear to seek light? Let us see what will happen if we keep a potted plant near a window of a room from which all the light comes. After a few days you will find that the tip of the plant has turned towards the open window. Reverse the position, i.e., rotate the potted plant so that the tip of the plant is turned towards the inside of the room, i.e., the side opposite the window. After a few days again observe the direction in which the tip is now turned. You will notice that the tip has once again turned to the source of light. This experiment shows that the growing tip turns towards the source of light.

You can do another experiment showing the effect of light on growth of plant in your classroom. Take a cardboard box and paint it black on the inside. Make a small window on one side of the box and place a potted plant in it. After some days you will find that the plant has bent towards the window through which the light was coming. Reverse the position of the plant, i.e., rotate the pot, so that the tip now faces the side opposite the window. After a few days again observe. You will find the stem has grown towards the light. Thus the stem always grows towards the light (Fig.5.8).

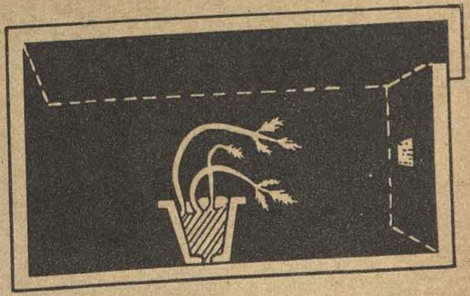

Fig. 5.8. Experiment to show that the stem tip turns towards light.

§ 4. Structure of Stem

In a plant the stem and the root are in continuation of one another and form one axis. While the stem normally is above the ground, the root is usually in the soil. Both these structures produce branches. But how will you distinguish a stem from a root? The root is usually pale, yellow or white in colour, particularly in the young plants and in small herbs. The stem in these plants is generally green in colour. The tip of a stem has usually a terminal bud but the tip of the root has a root cap. The root bears no leaves or even scars of fallen leaves. The stem bears leaves or the scars of fallen leaves. Stem usually has a bud in the axil of a leaf or above the leaf scar. These are the important differences between the stem and a root in their external structure.

Internal Structure

Take a thin cross section of a young stem of **sunflower** plant. Mount the section in a drop of water to which a drop of glycerine has been added. Put on a cover glass and examine the section with a magnifying lens. You will **find** that within the section the central area is lighter in appearance and the area around this has darker structures arranged in a circle. Outside this dark region is again a region of lighter area.

Now let us examine the section under the low power of a microscope. Make a note of the structure that you see from the outermost layer of the section to the middle of it (Fig. 5.9). You will find that the outermost layer consists of a single row of cells. This is the epidermis. This layer protects the

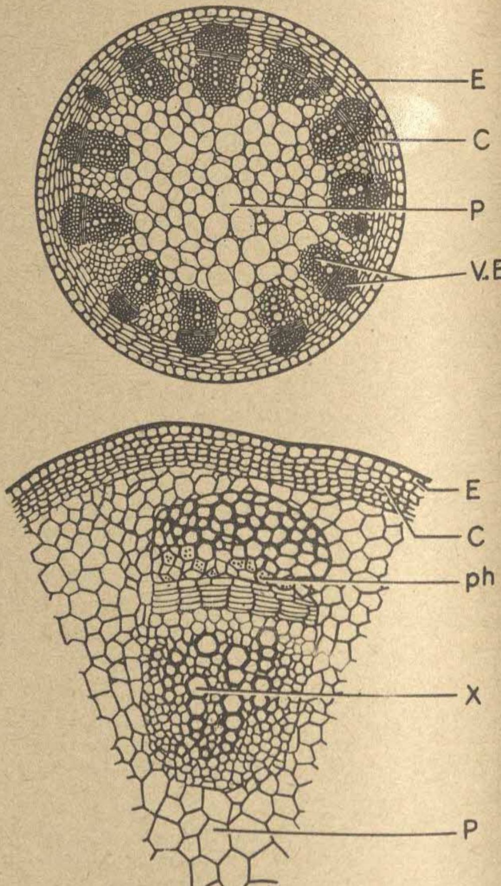

Fig. 5.9. The internal structure of a young stem of sunflower plant. H-hair; E-epidermis; C-cortex; X-xylem; Ph-phloem; P-pith

inner layers. Below this layer the stem consists of large thin-walled cells, many layers in thickness. These thin-walled cells form a tissue called **cortex.** Inner to the cortex are regions of darker areas. These areas appear darker because the cells are smaller in size and have richer contents or have thicker walls. These regions represent the **vascular bundles**. The inner cells of the vascular bundle, i. e., those towards the centre of the stem are thick-walled. This is the wood part of the stem. This part gives not only strength and support to the stem but also transports water and nutrients to the leaves. The cells are elongated, longitudinally. This tissue is called **xylem**. Outer to the xylem are thin-walled cells darker in contents. These cells help in the transport of prepared food from the leaves to the other parts of the plant. This tissue is called the **phloem**.

Inner to the circle of vascular bundles there are thin-walled large cells. This central tissue is called **pith** or **medulla**.

Growth in Thickness

How does the stem of a seedling grow in thickness? If you examine carefully a thin section of the vascular bundle under the microscope you will find that there are two or three layers of narrow cells between the xylem and the phloem. These cells are capable of dividing and increasing the number of cells towards the xylem and the phloem. These cells form the **cambium.** It is as a result of the divisions of these cells that the stem grows in thickness. The diameter of the stem increases. The addition of cells to xylem makes the stem hard. Examine the section of a stem which has grown in thickness. Do you see that the wood or the xylem part is in the form of a complete cylinder (Fig 5.10)? This wood forms the major part of the stem. External to this, the phloem along with cortex gets crushed with the expansion of the wood. Thus we get the woody stem of the shrubs and trees.

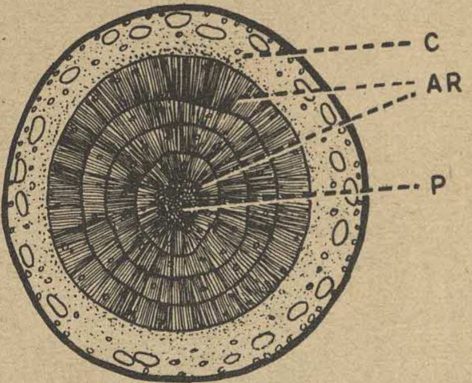

Fig. 5.10. Growth in thickness of a young shoot. Transverse section : C-cortex; A.R.-annual rings; p-pith

Have you ever seen a thick trunk of a tree when it has been cut transversely? Next time when you see a tree being cut on the road side or in a timber shop you closely observe the cut end of the trunk. You will find some dark concentric rings on the cut surface.

Each ring represents the growth in thickness of the stem during one growing season. Dark rings appear because of the difference in thickness of the cells of the wood during different seasons. During unfavourable seasons the cells will have thick walls, but in favourable seasons like spring the cells of the wood are larger and have thinner walls. The difference in their appearance separates the two zones and we see the wood of one season as a ring. These rings are called **annual rings** because, as stated earlier, each ring represents the amount of wood added during each year or growing season (Fig. 5.11). By counting the number of rings in a tree we can approximately state the age of the tree.

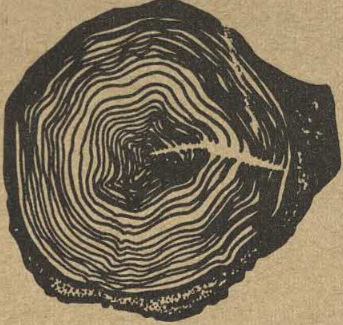

Fig. 5.11. Transverse section of a trunk to show annual rings

Why do the cells formed during spring have thinner walls and are larger in size ? The cells grow larger because of the greater activity during spring. Such wood with larger cells is called **spring wood**. The cells formed during autumn or winter have thicker cell walls and are smaller in size. This is because the activity of the cells is less during this season. The wood formed during winter is called **autumn wood**. Such distinct rings are very obvious in the trees of temperate regions. In tropical regions like India where the seasons are not so marked the distinction is not so clear.

When the stem increases in thickness what happens to the outer tissues like the cortex and epidermis ? These get broken, and in order to protect the living tissues inside, the stem forms another kind of cells known as **cork cells**. These cork cells appear in layers. The cork cells along with the dead cells of cortex and epidermis appear as bark. The bark of a tree shows a number of cracks and fissures. These provide a sort of ventilation for the inner live tissues of the cell. The cork which we use as stoppers for bottles are obtained from thick sheets of cork from cork trees. The cork tree is usually found growing in Portugal and some countries round the Mediterranean Sea. In these trees the cork is particularly thick being several centimetres in thickness.

§ 5. Functions of Stem

Conditions of Water and Mineral Nutrients

You have seen that plants absorb water through their root hairs. You have also learnt that along with the water the mineral salts dissolved in it are also absorbed. We studied that one of the functions of the stem is to conduct water and nutrients to the leaves. Let us find out with the help of an experiment as to how this happens. Dig up a young plant with its roots and wash it. Keep it in a beaker containing water with few drops of safranin added (Fig. 5. 12). After a few hours, take out the plant and cut the stem cross-wise. Do you see certain red spots in the section ? Why are these areas coloured red ? What does this experiment indicate ? The water and salts in solution absorbed by the roots are transported by the stem. The entire tissue of stem does not transport the solution. Only cerain specific areas in the stem transport the solution. These red spots correspond in number and position to the vascular bundles. It shows that the vascular bundles transport the solution in their tissues.

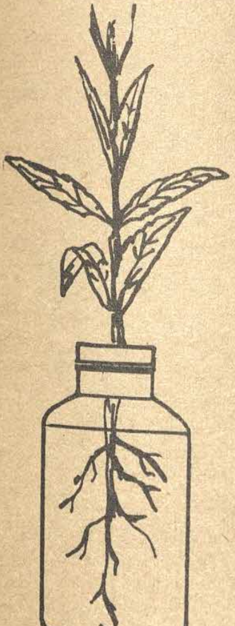

Fig. 5.12. Experiment to show that the transport of water and mineral nutrients to the leavestakes place through the stem

Transport of Organic Substances

Select any plant that usually gives off roots when a twig is cut off from it and left in water. Cut off a twig from the plant. Remove its soft part with a knife leaving the wood as a complete cylinder. This is called ringing. Remove the leaves found below the ringed area. Place the cutting in water and leave it for about a week. Observe what happens to portions of the stem above and below the ringed area. The cut end above the ringed area swells. A large number of roots arise from the swollen part (Fig. 5. 13). The lower end does not become swollen and very few or no roots appear. What does this indicate ? The food manufactured by the leaves could not be transported beyond the cut end. The accumulation of food causes the swelling of the region. Soon roots are formed here. The formation of roots requires food. By ringing the stem

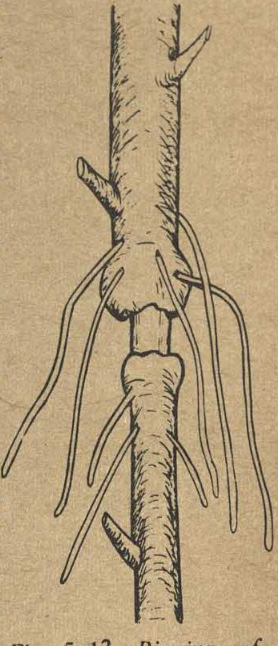

Fig. 5. 13. Ringing of a stem to demonstrate that organic substances are transported in the stem

the path of downward movement of food was blocked.

Support of Branches

The stem serves to support the leaves and branches. It helps the plant to stand the strain of bending due to wind.

Storage of Food

We have seen that the stems normally grow above the soil. But there are certain stems that grow underneath the soil. They sometimes resemble the roots. How do we call such structures as stems ? They possess buds. Buds are found only on stems and not on roots.

POTATO. This is a short, thick, fleshy part of the tip of a stem branch. The tips of branches underneath the soil gradually swell due to the accumulation of food materials. The 'eyes' of potato are its buds.

Take a very thin section of a potato and examine it under the microscope. The grain-like inclusions which you see are starch grains. Add iodine solution to a bit of potato. It turns blue. This indicates the presence of starch.

ONION. Cut vertically an onion bulb. The fleshy part which we eat are the leaves. Since the food material is stored in the leaves, they are thick and fleshy. Observe that the buds are enclosed by the fleshy leaves. Note that the leaves and buds are attached to a disc-like structure at the bottom. This is the stem. The roots arise from the base of the stem.

GINGER AND TURMERIC. The ginger and turmeric which we use in our curries are stems. These are short and fleshy with short internodes. If you examine carefully a bit of ginger you can see the white papery structure attached to some of the internodes. These are the reduced leaves. Since

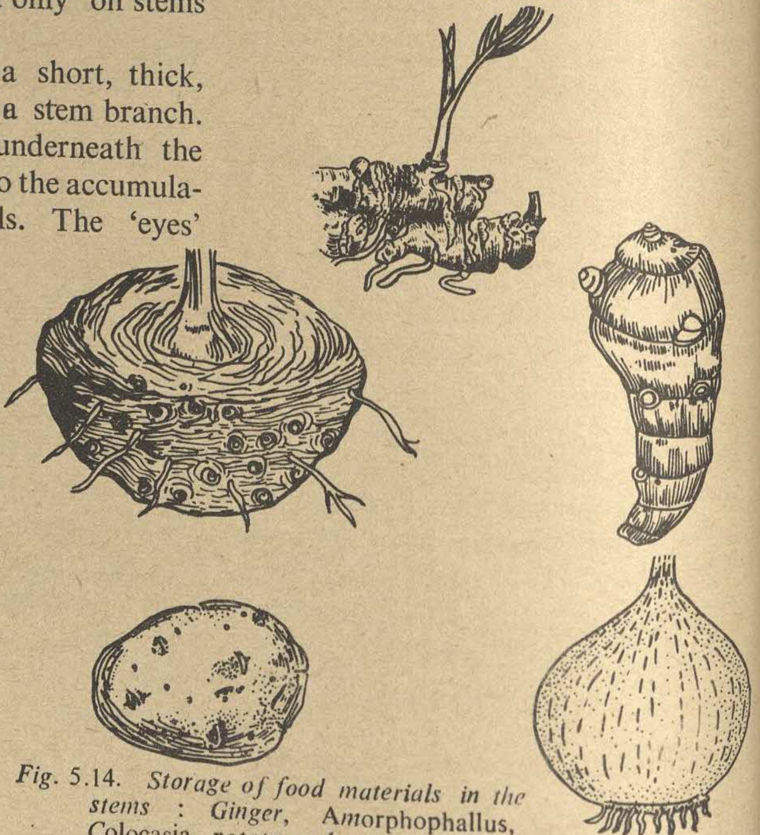

Fig. 5.14. *Storage of food materials in the stems* : *Ginger*, Amorphophallus, Colocasia, *potato and onion* they are developed underground, they lose their green colour.

Other examples of underground stems which we use as food are *zamikand*, *arbi* (*Amorphophallus*, *Colocasia*).

The wood of some trees is used as timber. It is used to make furniture like tables, chairs, cupboards, etc. It is also used for house building. Door frames, windows, etc. are made out of the timber trees. Teak and *sal* are good timber trees. Wood of some common trees is used as fuel. Some useful products are obtained from stems of certain plants. Sugar is manufactured from the juice of sugarcane. Sugarcane juice is a good drink during the hot summer. Jaggery is unrefined sugar. Rubber is made from the milky juice of the rubber tree. Jute is the fibre obtained from retting the stems of the jute plant. Cork, as already mentioned, is used as bottle cork, as insulation plates and in many other ways.

Some useful drugs are obtained from the stem or bark of medicinal plants. Quinine is a drug from the bark of the cinchona tree. Cinnamon used as a spice in cooking is the bark of the cinnamon tree.

Summary

The stem is the axis of the shoot to which the leaves are attached. The main functions of the stem are :

(*i*) conduction of water and mineeral salts from the roots to the leaves and transport of prepared food from the leaves to other parts ;

(*ii*) support of branches and leaves; and

(*iii*) storage of food.

Stems have buds in the axil of leaves or at the tips of shoots. Each bud is a condensed shoot, which later develops into a branch of the shoot. Besides the vegetative buds, there are also floral buds.

Stems are soft or hard and woody. They may be thick and erect or thin and twining or climbing.

A thin section of the young stem shows the following structure. It has a ring of vascular bundles around a pith. The vascular bundles have tissues which conduct water and mineral salts in solution, and another tissue to transport prepared food. The bundles are surrounded by cortex and the entire stucture is limited by the epidermis. An older stem shows growth in thickness. A fairly thick stem when cut across shows annual rings. Each ring represents the growth during one season. Outside the thickened wood, layers of cork are formed. The cork protects the inner layers.

The stems of plants yield many useful products. The wood is used for making furniture and other useful articles. The cork is used in many ways. Some drugs are derived from some plants and rubber from the rubber tree.

Questions

1. What are buds? Draw a bud in a longitudinal section and name the parts.
2. How do stems differ in various plants ? Name at least two types.
3. Describe the internal structure of a stem.
4. What are annual rings ? How are they formed ?
5. Name three important functions of stems.

Tasks

1. Collect different types of stems in plants, like the prostrate, climbing and creeping varieties. Make herbarium specimens of them.
2. Collect stems which are used by man. Display them on a stiff cardboard. Mention their uses.

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CHAPTER VI

LEAF : PREPARATION OF ORGANIC SUBSTANCES

Think of a tree and the picture before your mind is a big tree with a lot of green foliage. Small bushes and herbs also have green leaves. Most plants have green leaves. Have you ever asked yourself the questions, 'What is the role of the green leaf in the life of the plants ? Are they in any way useful to man ?' Many may not realize the great importance of leaves for the plants and for man and animals. It is in the leaves that the food required for the plant is prepared. In order to find out answers for the questions raised above it is necessary to study the structure of leaves, and the processes that take place in them, and also learn the relationship of leaves to other organs of the plant.

§ 1. Structure of Leaf

PARTS OF A LEAF : Let us study the leaf of a pipal tree as an example (Fig. 6.1). It is broad and thin and has a stalk at the base. The broad portion is the **lamina** and the stalk is called the **petiole.** The petiole is attached to the stem. The leaves of some plants like maize, wheat or rice have no petioles and such leaves are said to be **sessile.** On the blade are seen some prominent lines which are the **veins** of the leaf. There is a midrib running along the middle of the blade and branches from this spread out laterally. Later we will study the internal structure of this blade including the veins.

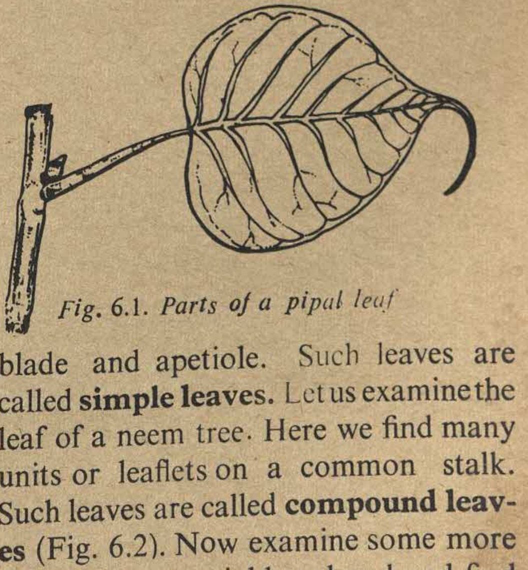


Fig. 6.1. Parts of a pipal leaf

SIMPLE AND COMPOUND LEAVES : The leaf of the pipal tree has a single blade and apetiole. Such leaves are called **simple leaves.** Let us examine the leaf of a neem tree. Here we find many units or leaflets on a common stalk. Such leaves are called **compound leaves** (Fig. 6.2). Now examine some more plants in your neighbourhood and find out whether they have simple or compound leaves. What is the difference

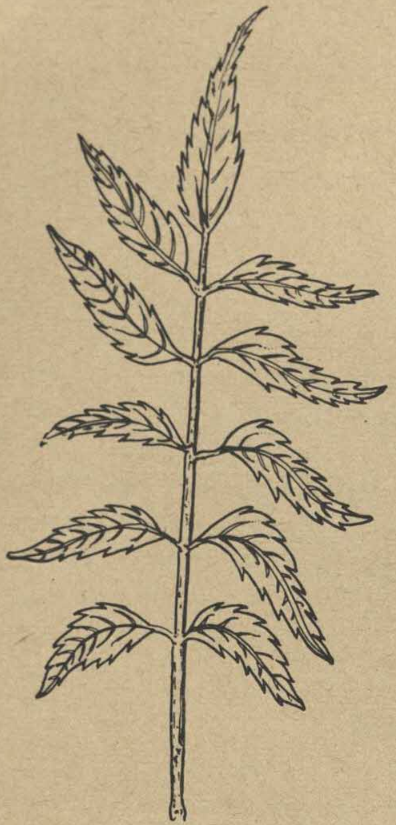


Fig. 6.2. A compound leaf of neem

between a compound leaf and a branch with simple leaves ? Why do you call the leaf of neem tree compound ? Examine carefully the axil of the pipal leaf. You will find an axillary bud (Fig. 6.1). Every leaf will have a bud in its axil. Now examine the axils of leaflets of a neem leaf. There are no buds. But you will find a bud in the axil of the leaf, that is, where the petiole or the main stalk joins the stem. Thus the compound leaf has only one bud in its axil and no buds in the axils of the leaflets. A branch with simple leaves, on the other hand, will have an axillary bud in the axil of each leaf.

SHAPES OF LEAVES : The shape of the pipal leaf is broadly oval. The base is broad and the apex is drawn to a fine point. The leaves of different plants will have different shapes. Collect some leaves of plants. Compare the shapes of these leaves. In size, the leaves may be very small or large. The leaves of the banana and those of the coconut palm are large. The largest known leaf is that of the giant water lily (*Victoria regia*). The leaves are circular with raised margins and have a diameter of two metres or more. In our country these are grown only in some botanical gardens.

VENATION : The veins of a leaf may be clearly visible when we examine the underside of a leaf or hold the leaf against light. In the pipal leaf you will find that the veins form a fine network. Sometimes you may collect among dry leaves a portion which has decayed, leaving only the network of the veins as a skeleton (Fig. 6.3). Many plants that we know have such a venation. This type of venation is called **reticulate.** Now look at maize leaf or a grass leaf or the leaflets of acoconut leaf. Here you see the veins running **parallel** to one another. All monocotyledons have leaves with parallel venation (Fig. 6.4). What are these veins ? Later you will see that these veins have xylem and phloem, the same tissues that are found in the vascular bundles of the stem.

LEAF ARRANGEMENT : When we see different plants and their leaves, we

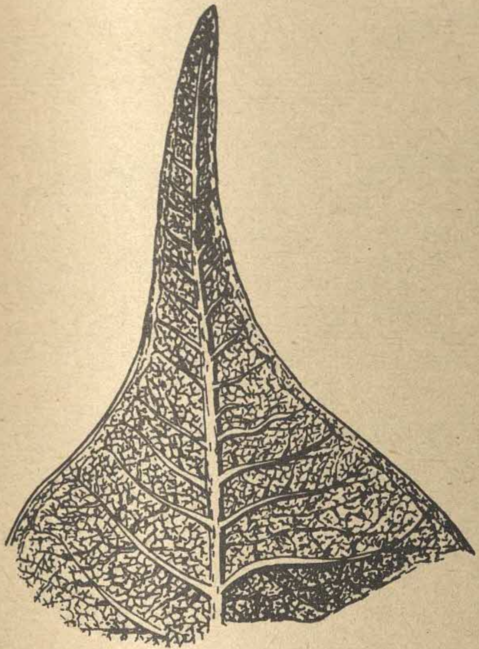


Fig. 6.3. Reticulate venation in a pipal leaf

All the leaves in a tree are so arranged that the leaves below will not be shaded by the leaves above them. The entire mass of leaves will try to receive as much sunlight as possible. The importance of this will be clear to us when we consider the main function of the leaf, namely, the preparation of food for the plant.

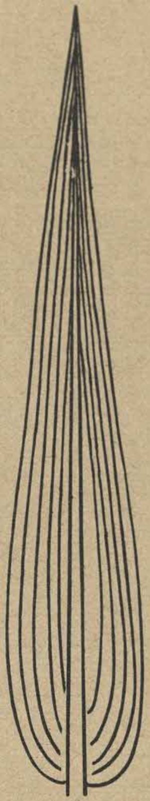


Fig. 6.4. Parallel venation in a monocot leaf

notice that the leaves are arranged differently on different plants. In some, like the pipal and the banyan, there is only one leaf at each node. Usually if the lower leaf is on the left side, the leaf above will be on the right side. Such an arrangement is called **alternate** (Fig. 6.5). Some other plants have two leaves at each node, one opposite the other. Such an arrangement is called **opposite** (Fig. 6.6). In some plants like the oleander or the yellow oleander, there may be more than two leaves at a node, and such an arrangement is called **whorled** (Fig. 6.7).

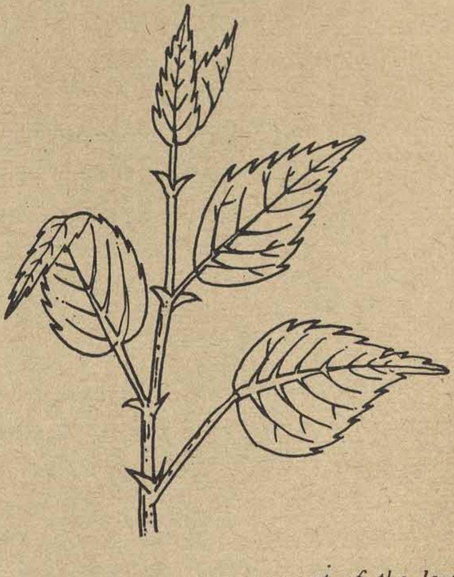


Fig. 6.5. Alternate arrangement of the leaves on the stem of china rose

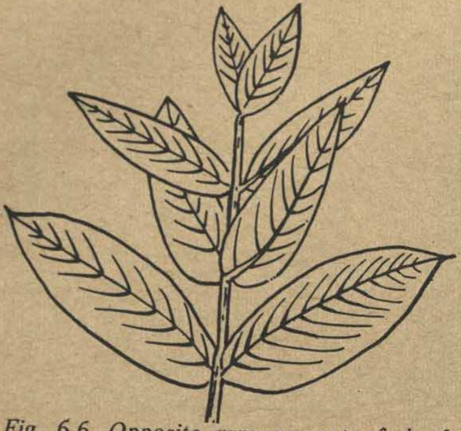


Fig. 6.6. *Opposite arrangement of the leaves on Calotropis stem*

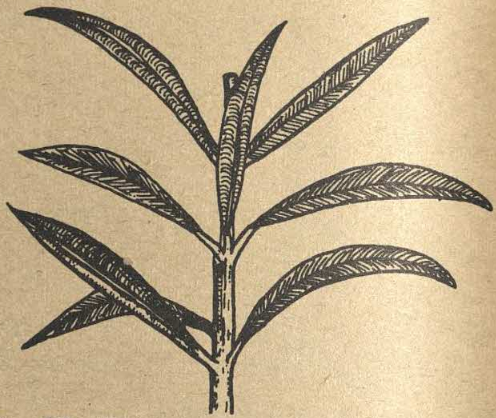


Fig. 6.7. *Whorled arrangement of the leaves on the stem (Nerium)*

Questions

1. What are the parts of a leaf ?
2. What are the two types of arrangement of veins you know ? In what plants do you find these types ?
3. How will you distinguish a simple leaf from a compound leaf ? State whether the leaves of neem, ashoka, rose and maize are simple or compound.
4. If a given leaf has reticulate venation, how many cotyledons will there be on the seed of the plant ?

Tasks

1. Examine the trees round about your school. Note which plants have simple leaves and which plants compound.
2. Prepare herbarium sheets of (*a*) simple and compound leaves, (*b*) leaves with different types of venation and (*c*) leaves of different shapes.

Internal Structure of a Leaf

The internal structure of a leaf can best be studied by examining a thin cross section of the leaf under a microscope. Cut out a piece of leaf and place it between two split halves of a block of carrot. This is to hold the thin leaf in position. Hold the block in the left hand and take thin section of the leaf along with the carrot piece. Float the sections in a watch glass with water. Select the thinnest section and mount it in a drop of water on a glass slide. Cover it with a cover glass, and now the preparation is ready to be examined under the microscope (Fig. 6.8).

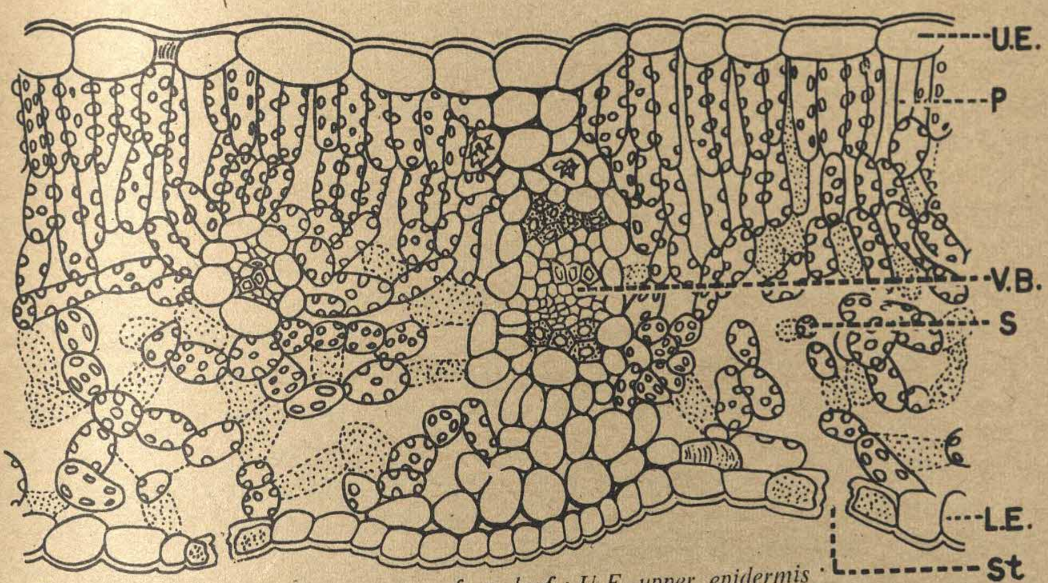


Fig. 6.8. The internal structure of a leaf : U.E.-upper epidermis P-palisade; V.B.-vascular bundle; S-spongy tissue; L.E.-lower epidermis; St-stoma

The first thing that will strike you is the fact that the leaf, like the stem and the root, has a cellular structure. The cells are of various sizes and shapes. You will find that on both sides of the section, that is, on the upper side and the lower side, there are single layers of cells which are almost similar to each other and equal in size. These are the **upper epidermis** and the **lower epidermis**. The cells seem to have no colour and are transparent. Their main function is to protect the inner cells.

The epidermis in cross section looks continuous. But when it is seen in surface view, as in a peel, you will find that it has many holes. Take any green leaf fairly thick and remove a peel from it as you did with the onion scale. Mount a bit of this peel in water on a glass slide and cover it with a cover glass. Examine it under a microscope. The cells of the epidermis are closely packed. The cells have wavy outer walls. Here and there will be tiny holes, as seen in Fig. 6.9. These holes are the **stomata**(singular **stoma**).

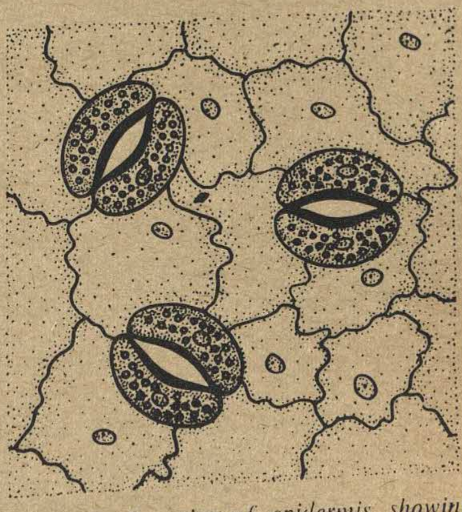


Fig. 6.9. Surface view of epidermis showing stomata

Each stoma has on either side a crescent-shaped cell which appears to be guarding it. These are called **guard cells.** While the other cells of the epidermis have no chloroplasts, the guard cells have chloroplasts. The stomata are the holes in the epidermis through which gases and water vapour enter or leave the air spaces in the leaf tissue. By changing their shape the guard cells are capable of closing or opening the stoma. The number of stomata is usually more in the lower epidermis. A single leaf of a plant will have thousands of stomata. Thus the tissues within the leaf have very good ventilation.

Between the two layers of epidermis are the tissues of the leaf. Most of these cells are green in colour. If you examine more carefully you will notice that the green colour is due to tiny green bodies within these cells. These tiny structures contain a green pigment in them called **chlorophyll.** The tiny structures are **chloroplasts.** The green pigment can be extracted from the leaf with the help of alcohol. The leaf is first boiled in water and then dipped in alcohol. This alcohol is further heated in a water bath. The green colour of the leaf passes on to the alcohol and the leaf becomes bleached.

The green cells are in several layers. Those under the upper epidermis are arranged close to one another with their length at right angles to the epidermal surface. They look like the fence posts or palisade and hence are together called **palisade tissue.** The cells in the lower half of the leaf are not so regularly arranged. They enclose a number of interspaces between them. Hence this tissue is called the **spongy tissue.** The two together, that is, the palisade and the spongy tissue, are called the **mesophyll.** This tissue is very important since their cells contain chloroplasts with the green pigment and it is in the chloroplasts that the food for the plant is prepared.

In the middle of the mesophyll you will find some tissues resembling vascular bundles. These are the tissues of the veins of the leaf which have been cut across. They have xylem on the upper side and phloem below. These two tissues have the same function as in the stem and the root. The xylem takes water and mineral salts to all the living cells of the leaf and the phloem transports prepared food in these cells. You will find the veins and their branches forming a fine network.

Try to keep a potted plant in the darkness for several days and later examine its growth and its new leaves. You will find that the shoot is lengthening and the leaves are colourless or pale yellow. If kept in the light for sometime, they turn green. Light seems to be essential for the formation of chlorophyll.

Questions

1. What is the structure of a leaf peel ?
2. What is the structure of stomata and what role do they play ?
3. Describe the sructure of a leaf. Draw figures and label the parts.
4. What is the green colour of the leaf due to ?
5. How do you prove that the green colour is due to a pigment ?

Task

Draw a schematic illustration of a section of leaf and colour the cells as you find them in the leaf. Name the parts.

§ 2. Functions of a Leaf

We have said that the green leaves are important for a plant because they are the organs in which the food for the plant is prepared with the help of sunlight. Now let us find out the details of some processes that take place inside the leaf, and the conditions necessary for these processes.

The plant body has many organic substances like starch, sugar, proteins and fats. We have already seen that a potato tuber is full of starch. You take a thin slice of potato on a slide and add iodine solution to it. See the section through a microscope. The section looks blue and through the microscope you can make out that the starch grains have turned blue. All fruits taste sweet. They have sugar in them. The sugarcane also has sugar in its juice. The cotyledons and endosperm in the seeds have plenty of food material which is organic substance. Any dry plant material when burnt gets carbonized. All these are organic substances. Where and how are these substances formed ?

Photosynthesis

The process of food manufacture in the leaf is called **photosynthesis.** *Photos* in Greek means light, and *synthesis* means putting together. It is so called because energy of the sun is used to prepare sugar in the leaf. The leaf absorbs carbon dioxide from the air and gets water through its veins. These are converted into sugar with the energy from the sun and with the help of green chlorophyll. In this process oxygen is evolved which escapes into the air.

FORMATION OF STARCH IN THE PRESENCE OF SUNLIGHT: Take a potted plant and place it in a dark room or inside a cardboard box and allow no light to enter. Keep it like this for at least 24 hours. Take care to see that the soil is not dry. Now after 24 hours or even two days take out the pot in semi darkness or twilight. Remove one leaf and keep it in a cardboard carton still in darkness. Select another leaf which is still kept attached to the plant. Take two pieces of black paper or slices of cork. In the centre of these papers a letter 'S' is cut. Cover part of the leaf with these pieces, one on the upper side and the other on the lower side. Pin them or clip them together (Fig. 6.10 a). Keep the potted plant in sunlight for at least 8 hours. Towards the evening remove the leaf from the plant and test it for starch in the manner described here.

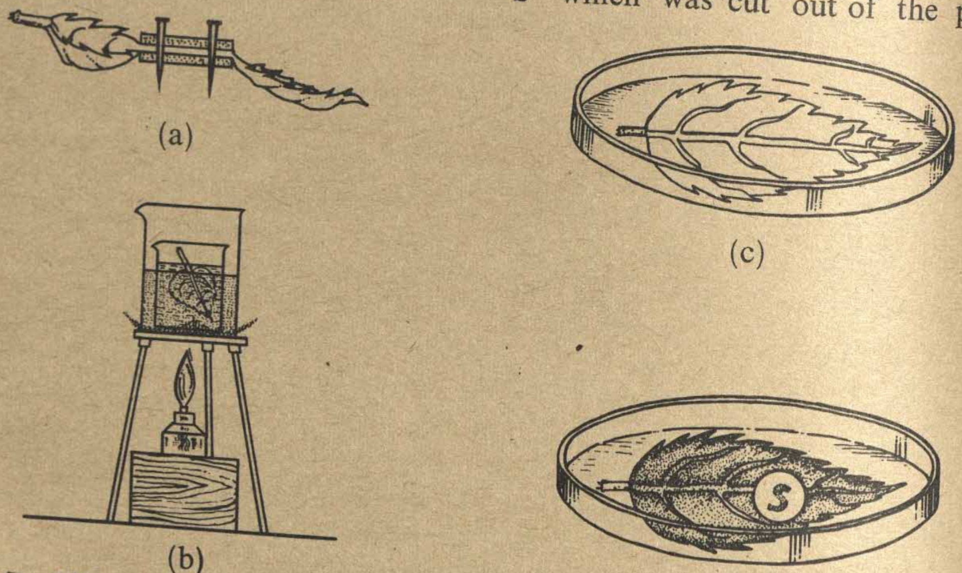

(a)
(b)
(c)
(d)

Fig. 6.10. (*a*) ,(*b*), (*c*), (*d*) *Stages in the experiment to demonstrate the formation of starch in the green leaf in the presence of light*

Remove the paper (or cork) pieces, and boil the leaf in water in a beaker for a few minutes. Then boil the leaf in alcohol. Care should be taken not to heat the alcohol directly. It will catch fire. Heat the alcohol in a water bath, i.e., the beaker with alcohol is placed in a bigger beaker or vessel with water and the water is heated (Fig. 6.10 b). The alcohol extracts all chlorophyll from the green leaf. Then wash the leaf in a petri-dish with water. The leaf is now bleached and colourless. Then add some iodine solution on the bleached leaf. Now you will find that the leaf takes on a tint of blue in all parts except those which were covered by black paper.

In our experiment the circular patch remains uncoloured except for the letter 'S' which was cut out of the paper. What does this experiment show ? This shows that the exposed parts of the leaf formed starch and the unexposed parts did not. Thus starch is formed in a leaf only in the presence of light.

Now repeat the experiment of bleaching the leaf that you plucked from the plant and kept in a covered box from the beginning of the experiment. Remember that this leaf was taken after keeping the plant in the dark for

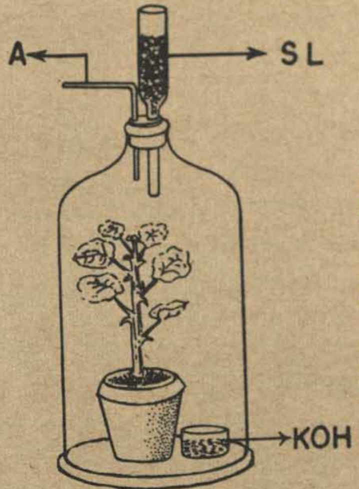


Fig. 6.11. Experiment to show the necessity of carbon dioxide for starch formation : A-aspirator; S.L.-slaked lime; KOH-potassium hydroxide

one or two days. Test the bleached leaf with iodine solution. You will find that no part of the leaf shows any presence of starch. All the starch that might have been in the leaf would have been removed during the time the plant was kept in the darkness.

STARCH IS FORMED ONLY BY THE GREEN PARTS OF THE PLANT : You may repeat the experiment by selecting plant with patches of green and yellow colour. You can get such a leaf from a croton plant. Treat the plant in the same way by keeping it in darkness for two days and then exposing the plant in sunlight for 6-8 hours. There is no need for any light screen (black paper or cork piece). Bleach the leaf as before and test it for starch. You will find that only those parts of the leaf turn blue which were green, but the yellow patches will remain uncoloured. This shows that the green pigment chlorophyll is necessary for the formation of starch.

CARBON DIOXIDE IS NECESSARY FOR STARCH FORMATION : Let us perform another experiment. Place a potted plant on a glass plate and cover it with a bell jar. Before covering the plant place a dish containing caustic soda or caustic potash solution inside the bell jar (Fig. 6.11). Apply vaseline to the edge of the bell jar, so that it is air tight and no air can enter the bell jar from outside. The bell jar has an entry for fresh air through a funnel at the top. This funnel has soda lime in it which will absorb the carbon dioxide. The other tube in the cork leads to an aspirator. Do all this work early in the morning before the sun has come up. The entire amount of carbon dioxide in the air present inside the bell jar will be absorbed by the caustic soda solution. Now place the plant with the bell jar in bright sunlight. After a few hours remove the bell jar. Cut off a leaf from the plant and test it for starch. The leaf should be decolourized first with alcohol and then tested with iodine. The leaf remains yellow. Starch is not formed in the green leaves in the absence of carbon dioxide although there is light. This means that starch is formed in the leaves of plants only when there is carbon dioxide present in the sourrounding air.

OXYGEN IS PRODUCED DURING STARCH FORMATION : We have now learned that light, chlorophyll and carbon dioxide are necessary for the formation of starch. If we leave a few small branches of aquatic plants in a vessel of water and leave it in sunlight we often find bubbles of gas escaping from the plant. What is this gas ? How is it formed ? Let us do this experiment and find out.

Take a glass with water and let carbon dioxide pass through it. Or, add a glass of aerated water to a beaker of water. Then place a few branches of an aquatic plant (*Hydrilla*) in the water. Invert a short-stemmed funnel over the plant and invert a test tube filled with water over the stem of the funnel (Fig. 6.12). Place the apparatus in the sun. Soon the aquatic plant starts producing gas bubbles. Test this gas with a glowing splinter. It will be seen that the gas is oxygen. Thus oxygen is produced by green plants in sunlight.

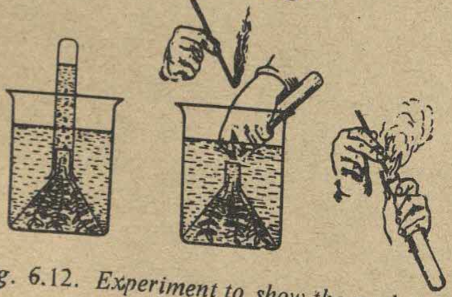


Fig. 6.12. Experiment to show the evolution of oxygen during starch formation

Our examination of the leaf structure and the experiments show us that light penetrates the transparent epidermis and reaches the green cells. The veins inside the leaf bring water to almost every green cell. The green cells have chloroplasts containing chlorophyll. The carbon dioxide required for starch formation enters through the stomata in the epidermis and the oxygen produced also escapes into the outer air through the stomata.

Thus the most important process in the life of a plant, namely, the production of food, takes place in the chlorophyllous part of the leaf. This process is called photosynthesis. The starch prepared by this process is used for the formation of other parts of the plant body. It is also stored in the seeds, roots and other parts.

The same food, starch or carbohydrate, is used again to provide energy for the cells to carry on other activities. This energy is produced during respiration, when sugar (a carbohydrate) is broken down to simple substances like carbon dioxide and water. Now let us compare the two processes—respiration and photosynthesis.

DIFFERENCES BETWEEN RESPIRATION AND PHOTOSYNTHESIS : We have noticed that germinating seeds respire. As a matterof fact all parts of a plant respire. During this process organic substances are used up. Oxygen is taken in and carbon dioxide is given off.

Formation of organic substances takes place only in green parts in light and during this process carbon dioxide is absorbed and oxygen is produced. In this process organic substances are formed and the whole plant grows.

Respiration and photosynthesis are the most vital processes in the life of a plant.

The differences between the two processes in plants can be stated in the form of a table.

Photosynthesis	*Respiration*
1. Carbon dioxide is absorbed	1. Oxygen is absorbed
2. Oxygen is produced	2. Carbon dioxide is produced
3. Takes place only in the pressure of sunlight	3. Takes place both during day and night time, both in light and in darkness
4. Takes place only in the cells containing chloroplasts or chlorophyll	4. Takes place in all cells of a plant
5. Organic substances are formed as a result of this process	5. Organic substances are used up

Questions

1. What are the conditions necessary for the formation of organic substances in the leaves ?
2. Describe an experiment to prove that starch is produced in plants only when there is light.
3. What are the substances used by the leaf for the preparation of starch?
4. What are the differences between photosynthesis and respiration ?

§ 3. Transpiration

The Importance of Water to Plants

All living plants have plenty of water in them. It constitutes nearly 80 per cent of the weight of the plant body. When there is lack of water, the plant is affected. The growth slows down. The stems of the soft herbaceous plants lie down on the ground and soon perish. Water is very necessary for plants in the various life processes. The plant absorbs mineral salts from the soil only in the form of solution in water. Water is necessary for the transport of food substances in the plant. Water is also necessary for photosynthesis.

A plant absorbs large quantities of water but utilizes only a small part of it. The rest of the water or the main bulk of water absorbed, evaporates mainly from the leaves into the air. This evaporation of water from a plant surface is called **transpiration.**

TRANSPIRATION : EVAPORATION OF WATER FROM PLANTS : That water evaporates from a plant can be demonstrated by conducting the following experiments :

Insert one leaf of a potted plant while still attached to the main plant into a flask and plug the mouth of the flask with cotton wool. Rest the flask

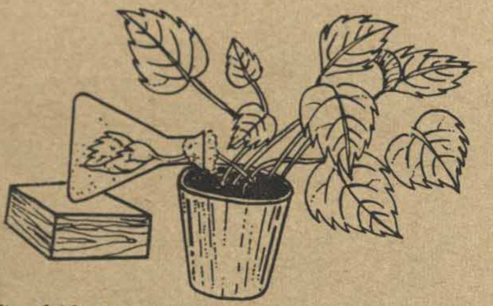


Fig. 6.13. Experiment to show the evaporation of water from the leaves

on a wooden block as shown in Fig. 6.13. Keep the entire apparatus, that is, the potted plant with the flask, in a warm lighted place. Take care to water the plant in the pot. In a few hours droplets of water appear on the inner walls of the flask. Where does this water come from? It should have come only from the leaf surface by evaporation.

We can measure the quantity of water evaporated by leaves during 24 hours. For this purpose take a bottle with water and introduce a twig of a plant with a number of leaves into the bottle (Fig. 6. 14). To prevent evaporation of water in the bottle, add several drops of oil on its surface. Take the weight of the bottle with the plant. Place the plant in the open for 24 hours and weigh the bottle again. The difference between the two weights indicates the quantity of water evaporated by the leaves in a period of 24 hours.

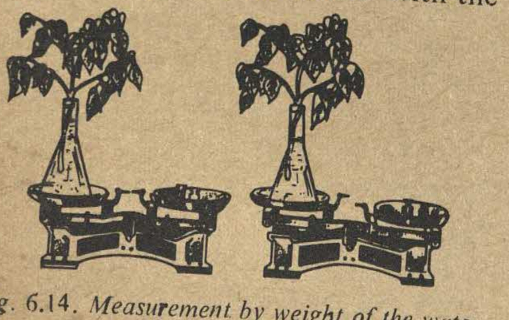


Fig. 6.14. Measurement by weight of the water transpired

How does the water evaporate from the leaf? You may think that the leaf has got an epidermis which would prevent evaporation from the surface. Let us recall the internal structure of the leaf. The green cell of the mesophyll have air spaces around them. All the air spaces in the leaves form a ventilating system. The air spaces are connected to the outside atmosphere through the stomata. The green cells have wet surfaces and hence water freely evaporates from the surface and the water vapour escapes into the external atmosphere through the stomata. In addition to the loss of water through the stomata, in some plants evaporation also occurs from the surface of the leaf.

In general, plants evaporate much water. The quantity of water evaporated greatly differs among different species of plants. For example, one fully grown maize plant evaporates during 24 hours anything from 200 to 800 litres of water. The same plant may evaporate different amounts of water under different conditions. Evaporation is rapid in sunlight than in the shade. Dry, strong winds also increase evaporation.

Evaporation of water is controlled to a certain extent by the fact whether the stomata are closed or kept open.

A plant can control the closing and opening of the stomata. Generally stomata are closed during night. During hot dry weather and lack of water the stomata may be closed during the day time which prevents evaporation of water. Thus the plant can regulate the rate of transpiration.

The Importance of Transpiration to Plants

We have just observed that a plant evaporates water from its leaf surface. Is this evaporation useful to the plant? It is suggested that transpiration helps in the absorption of water from the soil. The evaporation from the surface exerts a certain pull by the force of which water enters the roots through the root hairs. Another advantage suggested is that transpiration cools the plant to a certain extent. While the first suggestion is true to a certain extent, the latter advantage is doubted. Transpiration appears to be unavoidable.

Leaf Shedding

The plants shed leaves when they are old and when new leaves are formed. In places where the seasons are marked leaves are shed just before the cold weather. This can be seen in plants of hill stations. In some places where the trees are exposed to hot, dry air during a season, the leaves are shed before the adverse weather and the plant remains bare. Such plants are called deciduous plants. New leaves with bright colours are usually formed just after the first rains of the year. At this time the plant presents a very beautiful appearance.

Questions

1. What is transpiration ? Is it useful to a plant ?
2. How do you measure the quantity of water evaporated in a given time ?

Task

Find out whether the quantity of water evaporated by a plant depends upon the number of leaves or not. For this purpose take three test tubes. Fill the tubes with water. Mark the levels of water with pieces of thread. Select three branches of equal size from a tree or shrub. In one branch keep six leaves, in the other branch keep only two leaves and in the third only one leaf. Insert one twig in each tube. Add several drops of oil to the surface of water in the tubes to prevent evaporation. Observe the changes in the levels of water in the test tubes to find out in which test tube water evaporates most. Explain the results and draw conclusions.

§ 4. Importance of Green Plants in Nature and in Human Affairs

The Green Plants Act as Purifiers of Air

All living things like animals and plants absorb oxygen during respiration and produce carbon dioxide. The quantity of carbon dioxide in the air is further increased by the burning of fuel, the decay of plant and animal remains and the respiration of micro-organisms. In spite of these the total quantity of carbon dioxide in the atmosphere is not increased appreciably. It practically remains the same and always is constant. The carbon dioxide released is used by the plants which absorb it during photosynthesis. The green plants produce oxygen during this process. Thus green plants act as purifiers of air. If there were no green plants, life would be impossible on earth.

Green Plants as Producers of Organic Substances

The green plants are not only producers of oxygen but they have a still more important role in the life of animals and man. The green plants are the only organisms which can utilize sun's energy and prepare organic food from such simple substances like carbon dioxide and water. No animal or man can do this. The organic substances produced by plants are used by animals as food. The green plants are called

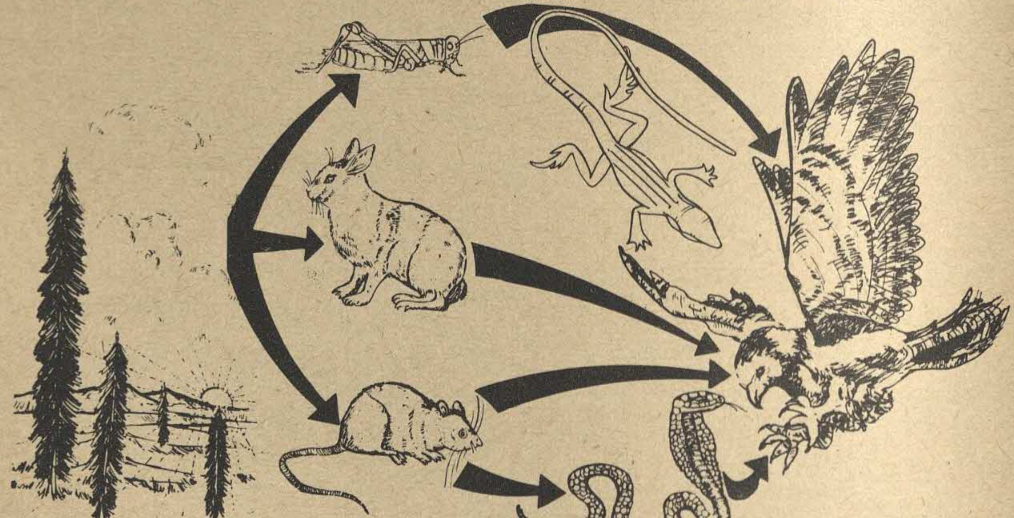


Fig. 6.15. Food web. Plants are the primary producers and the animals are the secondary producers. The micro-organisms at the bottom restore dead organic matter to the soil

the **primary producers** of organic matter and animals are called the **secondary producers** of organic matter.

Man cultivates useful plants. By growing plants he gets crops of grains (cereals), fruits, vegetables, potato, and root tubers. Thus man is able to collect a lot of food materials by growing plants. At the same time he cultivates fodder crops and grasses for feeding his cattle. Large quantities of organic substances are accumulated on our meadows and forests. Some are used for the preparation of hay and some for building materials and as fire wood. All these organic matters are formed in the cells of green plants.

Thus the plants, by being producers, are the first and the basic link in the food chain. Animals eat plants to get their food. Some animals do not eat plants but only other animals, but even these carnivorous animals are indirectly dependent on plants because the animals they eat are dependent on plants for food. Thus the lion may attack, kill and eat a deer. But the deer is dependent on herbs and leaves of the plants for food.

Protection of Plants

Because of this benefit alone, the green vegetation of earth should be protected. There should be no cutting of green branches without purpose. Trees and shrubs are grown in cities to enrich the oxygen content. In a well-planned city there are green belts of parks, gardens and lawns. The roads have avenue trees. Green plants help to preserve the health of the population. In our country, 'Vana Mahotsava' is celebrated every year when trees are planted and measures are taken to protect them. Afforestation measures are taken in the forest areas and hills. These measures increase the total plant population besides being useful in other ways. Every one should understand this great significance of green plants and preserve them from damage.

Summary

We have come to know that organic substances are produced in the leaves of green plants in the presence of light. For the preparation of starch, light, carbon dioxide and water are necessary. The green pigment of leaves helps in this process. Where there is no green pigment, no starch is formed.

Sunlight is necessary for the life of green plants. Without sunlight green plants cannot exist.

Animals feed on the food prepared by green plants. Animals cannot exist without plants.

The green plants have a great importance in the life of man. They give food, clothes, fuel, raw materials for industry, fodder for cattle and other materials for industry. The crops that are reaped in the fields are an accumulation of food substances produced and stored by green plants.

The plants purify the air by producing oxygen and taking up carbon dioxide.

The students and citizens must take an active part in planting trees and shrubs in towns and cities and in the preservation of the green mantle of earth.

Questions

1. What is the importance of green plants in the life of animals and man?
2. Why do we plant trees, shrubs and flowering plants in our towns and cities ?

CHAPTER VII

FLOWER : REPRODUCTION IN PLANTS

Apart from the green foliage, the flowers are the most striking structures in plants. Flowers are very attractive, have beautiful colours and sometimes a good scent. How are the flowers useful to the plants ? Every one of us knows that flowers produce fruits and that fruits have seeds. The mature seeds when sown give rise to new plants. Thus plants (flowering plants) produce their own kind through seeds. Such plants are said to reproduce through seeds. And seeds are produced in fruits which are developed from flowers. Thus flowers are important structures in plants. This is the most common method of increasing the number of the variety. Some plants are capable of increasing their number without producing any seeds or flowers. In these cases, parts of stem, roots or leaves give rise to new plants. This type of reproduction is called **vegetative reproduction.** We shall learn about this later in the chapter.

§ 1. Time of Flowering

Some plants have a few flowers in all seasons. But some trees and shrubs produce flowers only in particular seasons. Have you watched the avenue trees of Delhi soon after winter and when summer is about to begin ? The trees are in gorgeous bloom. *Jacaranda* is almost the first of the trees to bloom and later in May the *amaltas* (*Cassia fistula)* are in bloom. Thus different plants have different seasons for producing flowers.

§ 2. Structure of Flower

Let us examine the flower of *gul mohur* tree (*Delonix regia*). The flower has a stalk (Fig. 7.1) at the end of which are some floral parts. First you will find five triangular green structures. These are the sepals. In

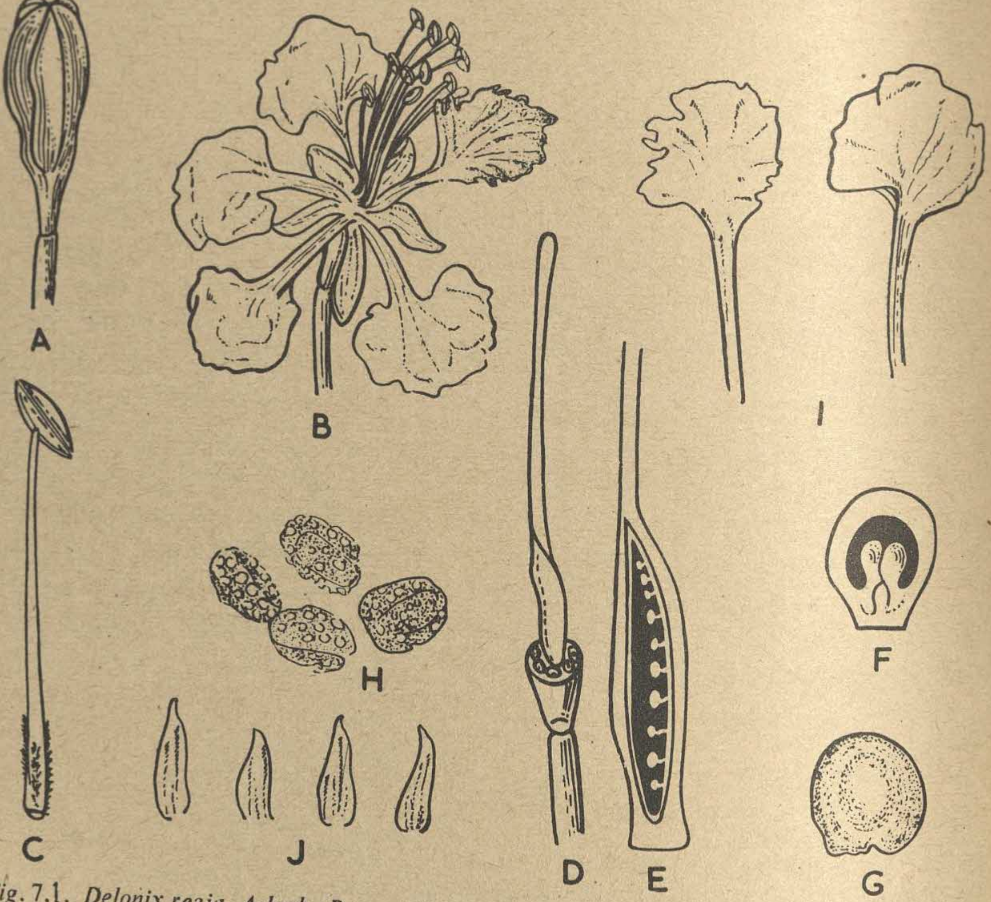


Fig. 7.1. *Delonix regia. A-bud; B-open flower; C-stamen; D-pistil; E-L.S. ovary; F-T.S. ovary; G-ovule; H-pollen grains; I-petal; J-sepal.*

the bud (Fig. 7.1) the sepals close over and cover the other more delicate parts of the flower. When the flower opens, the sepals separate and the parts inside are exposed. The parts next to sepals are the petals which are brightly coloured. These are the most attractive and conspicuous parts of the flower. Carefully separate the petals and see the next row of parts. There are ten long slender filamentous structures, each with a box-like structure at its tip. These are the stamens and they are also coloured red in the *gul mohur* flower. The box-like structures are **anthers**. They are two-lobed. If you open an anther, you will find inside fine yellow particles. These particles are the **pollen grains.** When all the stamens are removed you will find in the centre of the flower a single-chambered structure, long, broader at the base and tapering at the top. This is the pistil. The lower broader portion is the **ovary** and the slender elongated part is the **style**. The end of the style is sticky and is called the **stigma** (Fig. 7.1).

Try to cut the ovary with a thin blade along its length and see what is inside. You will find that there are small whitish structures attached to the margin of the ovary. These are the **ovules.** In a slightly matured ovary you will find that these structures have become the seeds. How do these ovules (immature seeds) become seeds? We shall learn how this happens later on.

The flower described just now has both stamens and pistil. Such flowers are called bisexual flowers. But some plants have flowers which have either only stamens (**staminate flowers**) or only pistils (**pistillate flowers**). Such flowers of only one kind are found in plants like cucumbers and the gourds (Fig. 7.2). The flowers in these plants are said to be **unisexual.** In these flowers fruits are formed only by the pistillate flowers. Fruits develop from the ovaries of the pistillate flowers. The pistil then is the female reproductive structure. The stamens in the staminate flowers are the male reproductive structures. Thus, in a flower the stamens and pistils are essential organs.

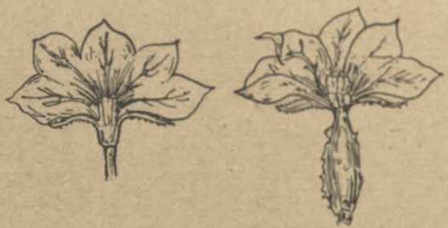


Fig. 7.2. Unisexual flowers: pistillate (right) and staminate (left)

§ 3. Inflorescences

Some flowers occur singly on the branches. Such **solitary** flowers are large and showy (China rose). In other plants, very often the flowers occur in clusters. In each cluster the oldest flower is below and the youngest near the apex. Each flower has its stalk or pedicel. The oldest flower at the bottom has the longest pedicel and the entire inflorescence has a conical appearance. Such an inflorescence is called a **raceme**. The inflorescence in *Cassia fistula* is a raceme (Fig. 7.3). Sometimes in an inflorescence all the pedicels may be of equal length and all the flowers appear to start from the same place. Such an inflorescence is an **umbel** as in *Lantana* (Fig. 7.4). Sometimes there may be a cluster of umbels as in *Pimpinella* (lady's lace Fig. 7.5). In sunflower, what people call a flower is really a cluster of several small flowers. The inflorescence is called a **head** inflorescence (Fig. 7.6).

In some flower clusters, the individual flowers have no pedicels. The flowers appear to start from the main branch directly. Such clusters are

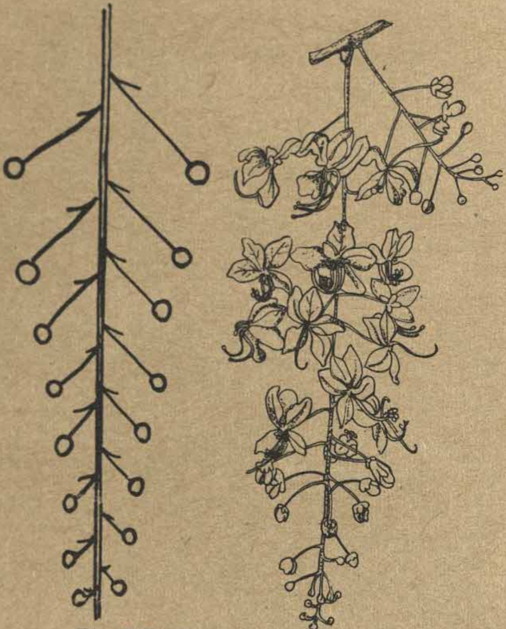
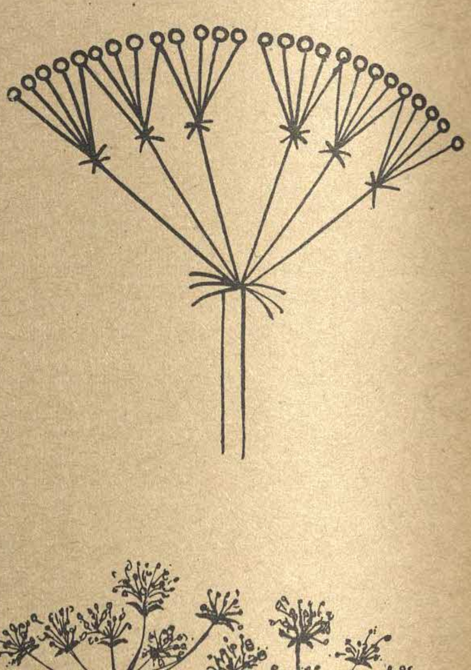


Fig. 7.3. Raceme in Amaltas



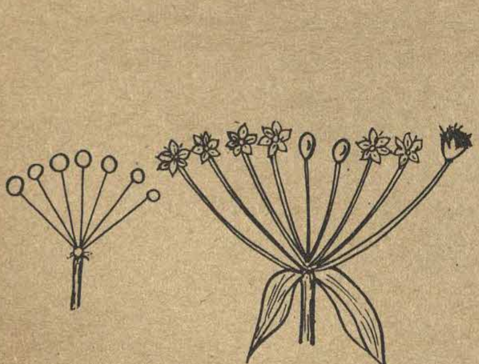


Fig. 7.4. Umbel in Lantana

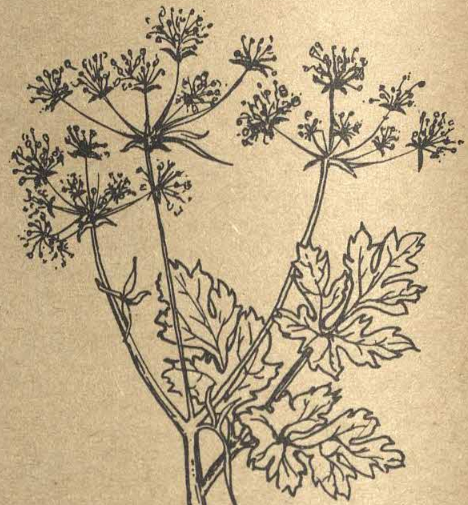


Fig. 7.5. Compound umbel in Pimpinella

called **spikes** (Fig. 7.7). *Achyranthes* and *Celosia* have spikes. Wheat or rice plants or grasses have complex spikes or branched spikes, i.e., clusters where many spikes together form an inflorescence.

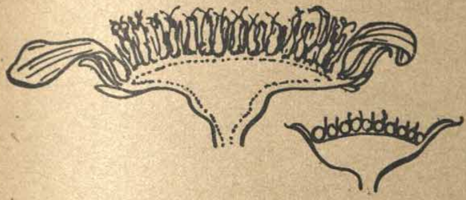


Fig. 7.6. Head in sunflower

In all the types described above the oldest flower was at the base and the youngest at the apex.

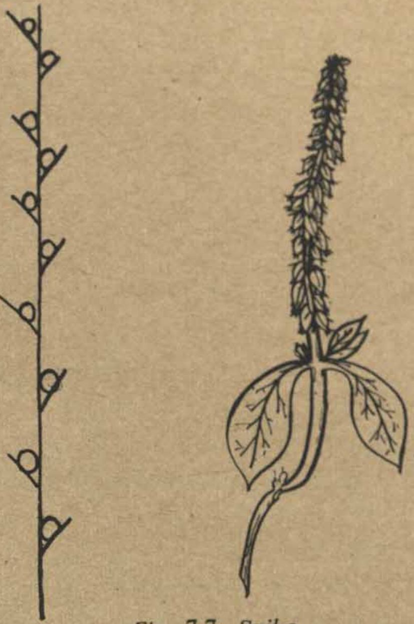


Fig. 7.7. Spike

In some, the oldest will be at the apex and the younger ones below. This is the case in jasmine where the middle flower is older and flowers on the sides are younger. This inflorescence is a **simple cyme**.

Questions

1. Which are the plants that have unisexual flowers ?
2. What type of inflorescence do wheat and rice plants have ?

Tasks

Examine the structure of pea or bean fruits.

Examine also the parts of the plants including the flowers. Examine other flowers like those of *Petunia, Salvia* and *Amaryllis.*

§ 4. Pollination

For the formation of fruits the pollen grains from the anthers should reach the stigma of the pistil. This transference of pollen grains is called **pollination.** The pollen from the anther of a flower may get deposited on the stigma of the same flower or on the stigma of another flower of the same plant. This is called **self-pollination.** When the pollen grains of a flower fall on the stigma of a flower of another plant, then it is called **cross-pollination.**

Pollination by Insects

How do the pollen grains reach the stigma which are far away ? The pollen grains are very small. They are either carried by wind to another flower or they are carried on the body of an insect which visits flowers for the nectar. In the case of some water plants the pollen may be carried by water currents.

In a garden with many plants in bloom you will find many moths, butterflies and bees hovering around flowers. If one of these is caught and its body and legs examined, you will see masses of pollen grains attached to them. When these insects visit other flowers the pollen grains will be transferred to the sticky stigma of the other flowers.

Flowers visited by insects are brightly coloured and are large. They are also often scented. They produce nectar, a sweet juice, and insects visit the flower to drink this nectar. Sometimes insects may eat pollen also as food. The structure of the flower is also suited to the visit of the insects. The insects land on a petal and enter inside. In *Salvia* (sage flower) the insect lands and pushes forward its head. In doing so it touches a small lever-like structure and the anther at the end of a long filament touches the back of the insect. When the insect visits another flower the pollen on the back of the insect gets stuck to the stigma (Fig.7.8). Jasmine flowers open only at night when moths visit them. Since they open at night they are not brightly coloured but are white. They have a sweet scent to attract the moths.

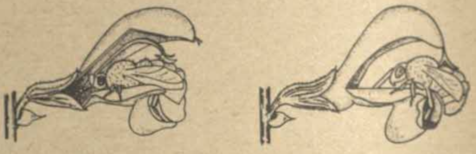


Fig. 7.8. Insect pollination in Salvia

When flowers are small they cannot attract insects individually. So they are clustered together as inflorescences so that in one visit an insect pollinates many flowers. The sunflower is an inflorescence with many small florets. When an insect alights on the flower head and moves about, it touches the anthers and stigma of many florets and thus brings about cross-pollination.

Pollination by Wind

Flowers in which the pollen is carried by wind are not coloured and they have no scent. They are also small in size. They produce no nectar. However, they produce a large quantity of pollen. While being carried by wind some are likely to be lost and hence a large quantity of pollen is produced. The stamens in some protrude out of the flowers, and the anthers open to shed the pollen only when the wea-

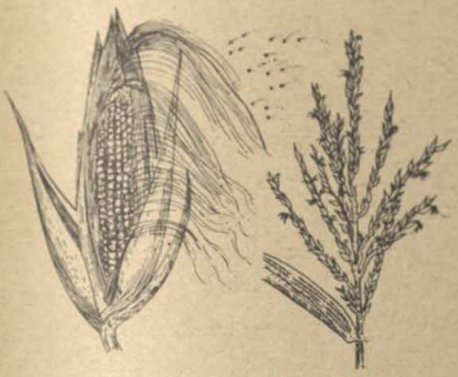


Fig. 7.9. Wind pollination in maize

ther is dry. The stigma also may be feathery and long (Fig. 7.9). The wind carries the pollen grains in its currents and the grains are caught in the feathery stigma. The maize plants and wheat plants are wind pollinated.

Artificial Pollination

Pollination by wind and insects is a natural process. Sometimes horticulturists or scientists bring about pollination by their efforts. Here the pollen from one plant is collected and deliberately dusted over the stigma of another flower. But before doing this, the anthers of the latter flowers are removed artificially. You can try this yourself. Select a *bhindi* plant with flowers. Open a mature flower bud and with a forceps remove all the anthers. From another just opened flower collect some pollen grains on a clean brush. Dust the pollen grains on the stigma of the first flower. Now make a paper cap and enclose this flower. After a few days remove the bag. The fruit formed inside the bag is due to pollination by you. Such a method is called **artificial pollination**.

Why do gardeners and horticulturists adapt this method of pollination ? This method will be useful to bring together two good qualities of two different varieties. Suppose variety 'A' has short fruits with less fibres and variety 'B' has long fruits but is full of fibres. We may desire to get long fruits but with less fibres. Then the artificial method of pollination can be tried between the varieties 'A' and 'B' and we can get a plant which will yield long fruits with less fibres.

Questions

1. What is the difference between cross-pollination and self-pollination ?
2. How is artificial pollination brought about ? What is its significance in agriculture ?

Task

Try artificial pollination in *baingan* plant and get a fruit.

§ 5. Fertilization

We have stated before that pollination is the first step in seed formation. What happens to the pollen grain that falls on the stigma ?

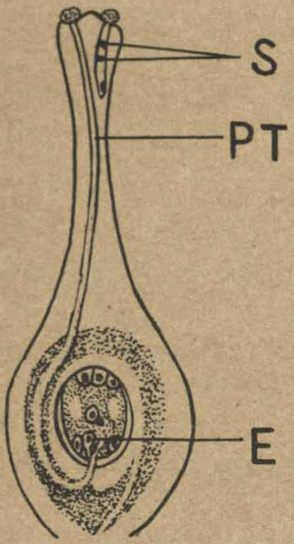


Fig. 7.10. The interior of the pistil at the time of fertilization; S-sperm; P.T-Pollen tube; E-embryo

Take some 3 per cent sugar solution in a shallow saucer. Shake some flowers on the surface of the solution so that a few pollen grains fall on it. Allow the solution to stand for some hours in a warm place. Examine the dish with a lens. Observe small tubes growing out from the pollen grains.

This is what happens when the pollen falls on the stigma. A long slender tube grows from the grain and pushes its way down through the style into the ovary. The tube grows along the ovary wall till it reaches an ovule. Inside the pollen tube near its end are formed two **sperms** or **male cells.** These take part in fertilization.

Each ovule has two coverings. The ovule forms inside a special structure, the **embryo sac**, which has about eight nuclei. One of these nuclei is the **egg** or the **female cell.** When the pollen tube has reached the ovule, it enters through a small hole in the coverings called the **micropyle.** The tube enters the embryo sac and then it bursts letting out the male cells. One of the male cells fuses with the egg cell. The fusion is called **fertilization** (Fig.7.10). The egg cell, after its fusion with the male cell, develops into the seeds and the ovary becomes the fruit. Thus the seed you examined earlier (Chapter 3) is the result of fertilization.

Summary

The flower is an important structure of a plant. It contains structures which form seeds. These seeds which contain small tiny plants grow into seedlings when suitable conditions are present. Hence, the flowers are useful in bringing about reproduction in plants. These plants are said to reproduce by seeds.

The flower has sepals and petals.

The latter are very often coloured and are attractive. The flowers also bear stamens and pistil which are the essential parts for reproduction.

The pollen grains are carried to the stigma by some agents like wind,water or insects. The grain produces a tube. The sperm cell in the grain travels down the tube and enters the ovule. When it reaches the egg-cell, sperm cell fuses with it. The fused cell develops into an embryo. This is fertilization.

Fertilization stimulates the ovule to become a seed and the ovary to develop into a fruit.

Questions

1. How is fertilization brought about ?
2. What structure does the ovule become after fertilization ?
3. What is formed from the ovary after fertilization ?

§ 6. The Fruit and the Seed

After fertilization of the flower, the sepals, petals and stamens drop off. The ovary grows larger and larger and becomes the fruit. Inside, the ovules also develop into the seeds. The wall of the ovary may become either fleshy or in the mature fruit it may become dry. The former kind of fruits are called '**fleshy fruits** and the latter **dry fruits.**

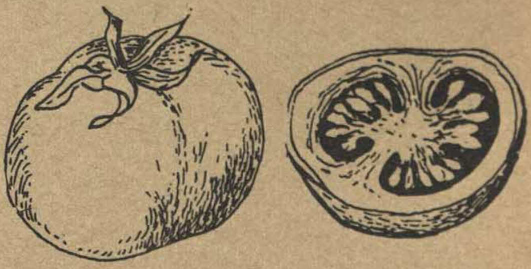


Fig. 7.11. *Berry* (*Tomato*)

Fleshy Fruits

In some fleshy fruits there is an outer skin and the rest of the fruit is pulpy and succulent. The seeds are embedded in this pulp. Such a fruit is called a **berry.** The grape, tomato, *baingan* and the banana are all berries (Fig. 7.11). Another variety of the fleshy fruit is the **drupe.** Here the fruit has a skin, a pulpy part and a hard stone (Fig. 7.12). The seed is enclosed inside the hard shell. The mango is a drupe. The coconut is also a drupe, but here the middle fleshy part has become fibrous. The fibres are the coir fibres. Many useful articles are made from these fibres. The nut inside the hard shell is the seed of the coconut. The *ber* is also a berry

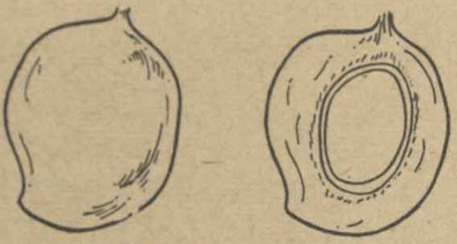


Fig. 7.12. *Drupe* (*Mango*)

with hard stones inside. All the gourds like the cucumber, pumpkin and the watermelon are fleshy fruits. The skin of some of these are tough and thick. The orange is a fleshy fruit where the rind is the fruit wall. The juicy hairs found inside are internal outgrowths from the fruit wall.

All fleshy fruits let out the seeds only when they decay or when some animal or man eats the fleshy part and throws away the seed. The seeds get dispersed this way. Because of their useful nature man cultivates certain varieties and collects the seeds.

Dry Fruits

The fruits whose walls become dry in the ripe condition are dry fruits. These fruits mostly open in various ways in order to expel their seeds, others may not open at all but remain closed. Their seeds are shed only when the fruit wall decays.

The dry fruits are either one-chambered as in bean and *Cassia* or many chambered as in China rose, *bhindi* or cotton. The fruit in bean, pea or the rain-tree is called a **legume** or **pod** (Fig. 7.13). The fruits are flat, one-chambered with the seeds attached to one margin.

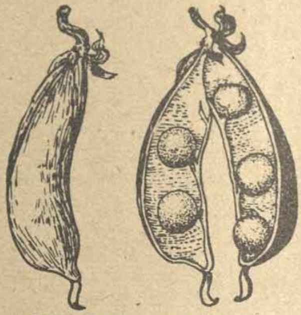


Fig. 7.13. *Pod* (*Pea*)

The fruit with many chambers as in cotton is a **capsule** (Fig. 7.14). There are many other varieties of dry fruits which open.

Fig. 7.14. *Capsule* (*Cotton*)

In the sunflower plant, the fruit is small and it encloses one seed which almost fills the fruit. But the fruit wall can easily be separated from the seed. This fruit is an **achene** (Fig. 7.15). In

Fig. 7.15. *Achene* (*Sunflower*)

Fig. 7.16. *Caryopsis* (*Maize*)

wheat and paddy the fruit is similar but the fruit wall is completely fused with the seed coat and cannot be separated from it. The fruit is a **caryopsis** (Fig. 7.16).

Apart from these types there are fruits which are really not fruits. The apple is a **false fruit.** The thick fleshy part is not the fruit wall (Fig. 7.17). This is the swollen receptacle of the flower.

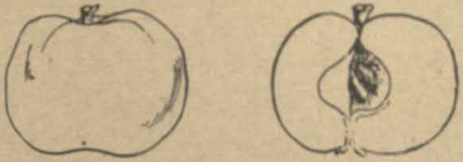


Fig 7.17. False fruit (Apple)

§ 7. Dispersal of Fruits and Seeds

On germination, a seed develops into a new plant. But the seeds must fall on suitable ground where the conditions are favourable, before they can germinate. The plants have methods of dispersing their fruits and seeds far away from the place where they grow. When the fruits or seeds are dry and small they are easily carried by winds. Often such seeds or fruits develop wing-like outgrowths. The seeds in many plants like *Calotropis* and *Tridax* have tufts of hair on top of the seed. The seeds float in air (Fig. 7.18); the tufts of hairs act like parachutes. The fruits themselves may be flat and develop wing-like outgrowths. Such fruits are carried far by wind currents. The fruits of *Combretum* and *Ventilago* have wings.

Have you ever walked bare-footed in open places? It may be that sometimes you were walking on weeds and you were pricked by a thorny fruit. *Tribulus* is a troublesome weed which has such thorny fruits (Fig. 7.19). You walk among herbs and you find small fruits attached to your clothes. Presence of thorns and prickles on fruits is one of

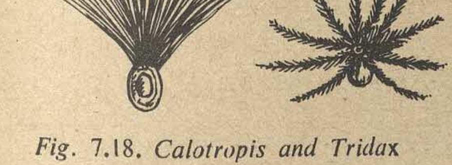


Fig. 7.18. Calotropis and Tridax

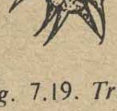


Fig. 7.19. Tribulus

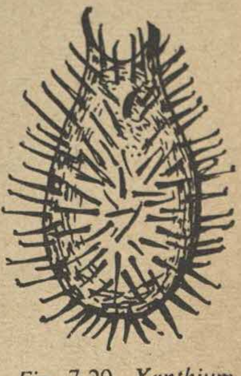


Fig. 7.20. Xanthium

the means by which plant seeds get dispersed. *Xanthium* fruits may stick to the wool on sheep and get carried to distances (Fig. 7.20).

Currents of water may help seeds and fruits to be floated far from where their parent plants grow. Coconut fruits are known to be carried across the oceans to the shores of other countries and islands (Fig. 7.21).

Fig. 7.21. Coconut fruit

Men and animals help in the dispersal when they collect fruits or seeds for their edible parts and throw away the seeds.

Summary

Fruits are of two kinds. They may either be fleshy fruits or dry fruits. Some of the latter split open to throw out the seeds. The fruits and seeds get dispersed in many ways. Seed dispersal is necessary for the variety to spread to new surroundings and to maintain the species.

§ 8. Vegetative Reproduction

Normally reproduction is effected by seed formation in most flowering plants. The male cell in the pollen fuses with the female cell in the ovule and the fused cell develops into an embryo or a tiny plant. The ovule becomes a seed. Since there is a fusion of sex cells before the seed is formed, the reproduction is also said to be **sexual**. But there are many plants which reproduce or increase their number without forming gametes or seeds. This method is called **vegetative reproduction.**

In the kitchen you must have often found potatoes and onions sprouting into small plants. Again, around a big banana tree, you often find smaller banana plants. A gardener separates these baby plants and plants them elsewhere, where they grow into new banana plants.

How to Grow Plants without Seeds

You can try to grow a potato plant without using its seeds. Take a potato tuber and cut it into bits so as to include one 'eye' in each small piece. Sow the pieces inside a flat-box containing a mixture of sand and saw dust. Moisten the pot generously. In about ten days new plants of potato come out (Fig. 7.22).

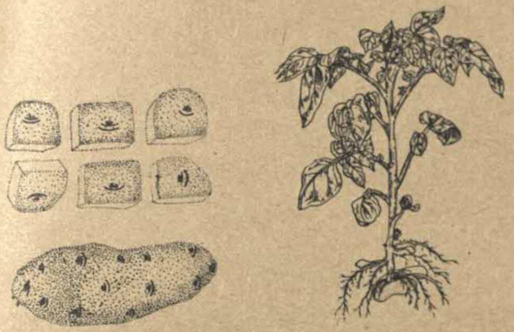


Fig. 7.22. Vegetative reproduction in potato. Left—'eyes' of potato, Right—new plant

Bring a *Bryophyllum* leaf from the garden and put it on moist saw dust or sand. Keep it moist for a week. You will note small plants with roots and shoots coming out from the notches of the leaf. When such a tiny plant is separated, it can grow into a new plant. This method of raising new plants without using seeds is known as **vegetative propagation** (Fig. 7.23).

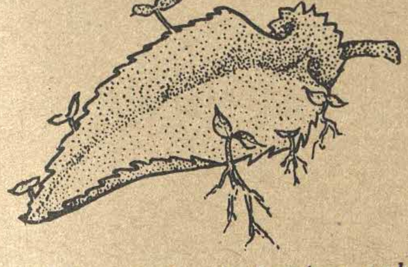


Fig. 7.23. Bryophyllum leaf with new plants in the notches

Vegetative Reproduction in Practice

Some crop and vegetable plants are grown only by vegetative propagation. These are the potato, the sugarcane and the banana.

In all these plants, stems are used for vegetative propagation. The sugarcane is so cut that each piece has two nodes and an internode between them.

Examine the many small dot-like structures at the node. These are rudimentary roots. You will find a small bud protruding just above the line of roots. The small piece of sugarcane including nodes and one internode is called a '**set**' or **cutting** (Fig. 7.24). On planting this 'set' roots develop from the nodes and the bud grows out into a sugarcane plant.

Keep some lengths of sugarcane stem (2 or 3 internode-lengths standing in a few cm depth of water in tall jars. After a few days, observe these. You would find that the pieces have developed roots at the nodes.

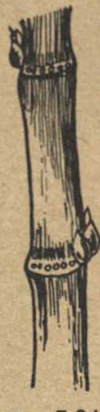


Fig. 7.24. Sugarcane set

Vegetative Reproduction by Roots

The underground roots of sweet potato, asparagus and tapioca become swollen for the purpose of storing food. We use these roots as food. It is possible to grow from the swollen roots of sweet potato or asparagus a number of new plants.

Place some cut pieces of sweet potato tuber in the soil in a flower pot. Sweet potato plants will grow from the tuber (Fig. 7.25).

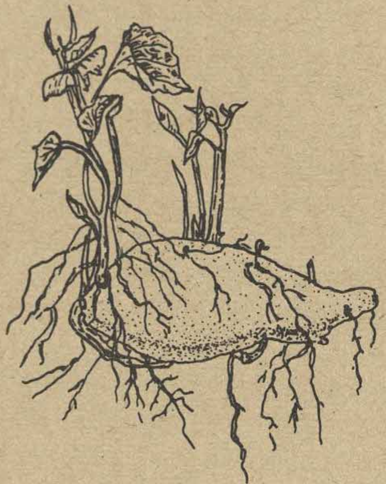


Fig. 7.25. Vegetative reproduction by root in sweet potato

Vegetative Reproduction by Stems

The underground stems of potato, ginger, onion or turmeric store food materials. How are these plants grown? In the potato tuber you will find many 'eyes'. Each eye is a bud with a scale leaf or the scar of it. In ginger also, at the nodes one finds scars and small scale leaves. If a portion of a potato with an 'eye' is sown, it will grow into a new plant.

Fill three garden-pots with a mixture of sand and saw dust. Cut a potato tuber into small pieces so as to include one 'eye' in each and sow these pieces in one pot. In another pot, place cut pieces of ginger, each containing a bud. Separate the buds of onion and sow all of them in the third pot. In a few weeks you will see that small plants of potato, ginger and onion have sprouted. Uproot some small plants of potato, onion or ginger. Do you see nodes, internodes and small leaves ?

Some plants send out slender stems which creep on the surface of the soil. These are **stolons** or **runners** and they produce smaller plants which strike roots at some distance from the original plant, as in *Hydrocotyl* (Fig.7.26).

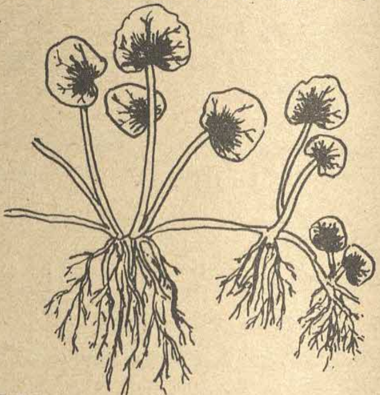


Fig. 7.26. Vegetative reproduction by the stem of Hydrocotyl

Banana is another plant which reproduces only by vegetative methods. The banana has big stocky underground stem from which smaller shoots start growing. When they come out of the ground they form small plants which are called 'sword suckers' (Fig.7.27). If separated from the mother plant and planted these develop into new plants. The banana plant has almost lost the power of reproducing by seeds.

Sugarcane has already been mentioned as a plant which is grown vegetatively.

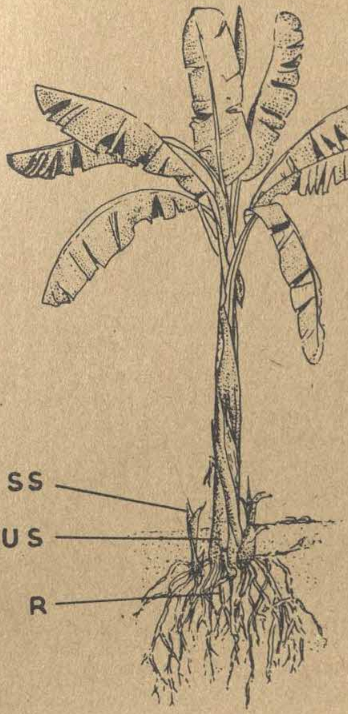


Fig. 7.27. Vegetative reproduction by stem in banana S.S-sword sucker; U.S-underground stem; R-root

Fig.

Questions

1. How do you know that potato and ginger are underground stems and not roots ?
2. Where is the stem in a banana plant ?
3. How does a farmer raise a sugarcane crop ?

Vegetative Propagation : Some Practices

Fruit trees like mango, citrus, apple and pear are raised vegetatively. Thus the quality for which a particular type is selected is maintained. We may select a mango variety for fibrelessness, a citrus for its sweetness and juice contents.

All these fruit trees are grown by some method of vegetative propagation. It may be a cutting, layering or grafting. In all these a portion of the mother plant is separated and grown independently into a new plant.

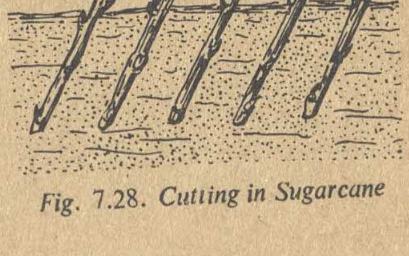


Fig. 7.28. Cutting in Sugarcane

CUTTING : A fairly mature stem of rose or *Coleus* can be cut and planted in moist soil. After a few days the cutting develops roots at one end and small shoots at the other. Crotons in a garden are raised by this method.

LAYERING : In layering, part of the branch of the plant is bent and kept below the soil. Sometimes the stem is cut a little on one side so as to induce root formation (Fig. 7.29). After a few days or weeks, roots develop at the buried region of the stem. Now this stem can be separated from the mother plant and grown as an independent plant. Jasmine can be propagated by layering.

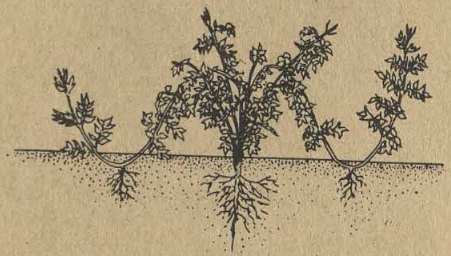


Fig. 7.29. *Layering in jasmine*

GRAFTING : Grafting consists of growing a piece of one plant on a cut piece of another rooted plant. In grafting, a cut is made on a small piece of one stem (of the desired plant) and this cut end is placed against the cut end of a stem which is still rooted in a pot. The united cut portions are covered by parchment paper and sealed with wax (Fig.7.30). After a few days the cut ends fuse. The two pieces become one unit. The cut piece which is united is called the **scion** and that which is potted is known as **stock**. The united stem piece starts forming shoots and grows into a new plant. This is only one method of grafting. There are also other mothods of making a graft.

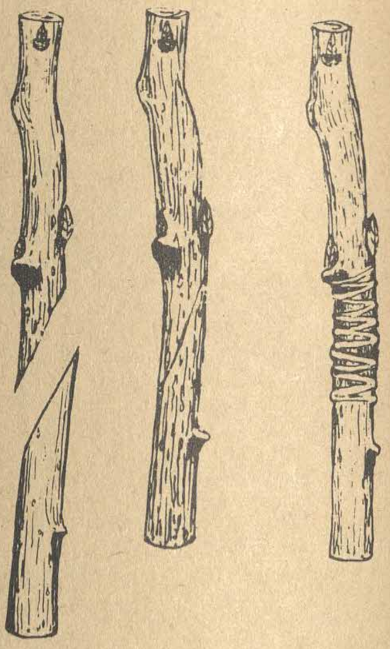


Fig. 7.30. *Grafting in mango*

Grafting is a method adapted where the good qualities of a plant are to be preserved. Thus if a mango plant yields good fruits full of fleshy pulp with no fibres, then these qualities will be preserved if the subsequent plants are raised by grafting. If seeds of such plants are grown then the seedlings when they grow into mature plants may not yield fruits of the same quality. The scion is always the desired plant and the stock can be of any other variety.

Is Vegetative Reproduction Better than Reproduction by Seeds ?

We have seen that many plants that are useful to us are raised by vegetative propagation. Such propagation of plants through vegetative means is advantageous in many respects. The new plants raised resemble the parents in all respects, and retain all characters of the plants. And thus we are sure of getting the same kind of plants. In the sexual method of reproduction, the offsprings often show some differences from the parents. This does not happen in vegetative reproduction. Good and useful characters, such as yield, resistance to disease, etc., are retained by adopting vegetative propagation.

Summary

Most flowering plants reproduce by seeds. There are a few which reproduce by other methods than by seeds. Such vegetative propagation occurs naturally and it can also be induced artificially.

Many plants reproduce vegetatively by roots (sweet potato and tapioca) or by stems (potato and ginger) or by leaves (*Bryophyllum*). Jasmine and rose can be propagated by cutting or layering. Fruit trees are propagated by grafting. Apple and pear trees are also raised by grafting.

Questions

1. What is cutting ? Describe how we can get a new plant of rose by cutting ?
2. Name two common trees which are propagated by grafting.
3. What is a scion ?

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CHAPTER VIII

PLANT AS A LIVING ORGANISM

A flowering plant has root, stem, leaves, flowers, fruits and so on. All these organs are made up of cells and tissues. All the organs together form an entire plant. These organs carry on their respective special physiological processes like respiration, assimilation, growth and reproduction. There is co-ordination between the functions performed by the different organs, and the plant continues to live as a single organism. The main function of one organ may be assimilation, that of another absorption of food materials and that, of a third one, giving mechanical support to the plant. Still, all these organs respire and exhibit other features of living tissues.

The flowering plants are capable of living under various climate conditions all over the world. Plants of a particular region adapt themselves to their surroundings. You have learnt about various types of plants. In some plants like the cactus, the stem is flat and green and it carries on the functions of a leaf. The leaves are reduced to spines. Some trees like the mango or the *jamun* are big with plenty of dark green leaves. The leaves perform the important function of assimilation. Thus whether the plant is found in a desert or in a forest, whether its parts are modified or not, each plant lives as single organism.

Man selects the plants which are very useful to him. He tries to grow these plants. He gives them necessary conditions for good growth. The wheat plant provides man with an important foodgrain. Man cultivates wheat in the best possible conditions like good water supply, good soil, manure and fertilizers, optimum time for sowing and harvesting.

§ 1. Some Features of a Plant

How does a plant live as one organic unit ? How does it coordinate the work of its different organs ? Let us take a plant (Fig. 8. 1) like the sunflower and see how it behaves like a single organism.

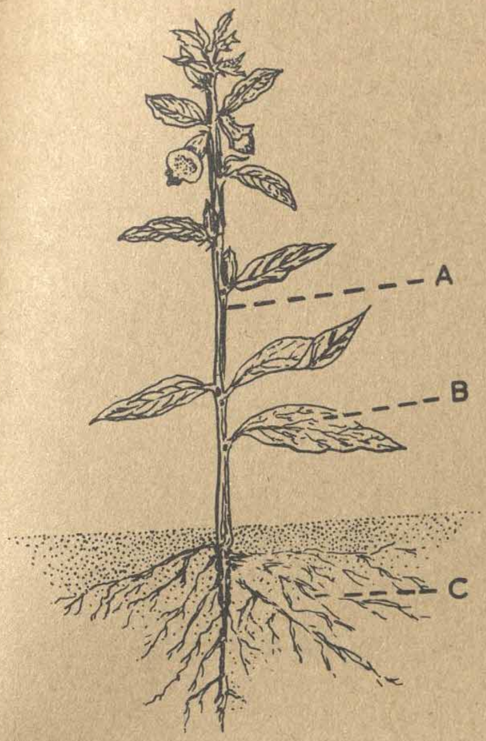

Fig. 8.1. *Parts of a flowering plant. A-stem; B-leaf; C-root*

The Root and its Function

The sunflower plant has two parts. One part is underground and this is the root system and the other part which is above the ground is the shoot. The roots fix the plant to the soil and at the same time absorb water and mineral salts from the soil. Salts are absorbed in the form of solution. The root hairs are in intimate contact with the soil particles. They absorb the water which occurs as a thin film around the soil particles (Fig. 8.3). This water is taken to the central portion of the root where through the xylem vessels they are transported upwards. This transportation continues in the stem also.

The Stem and Transport of Material

In most plants the stem keeps the plants erect. Inside the stem, the water

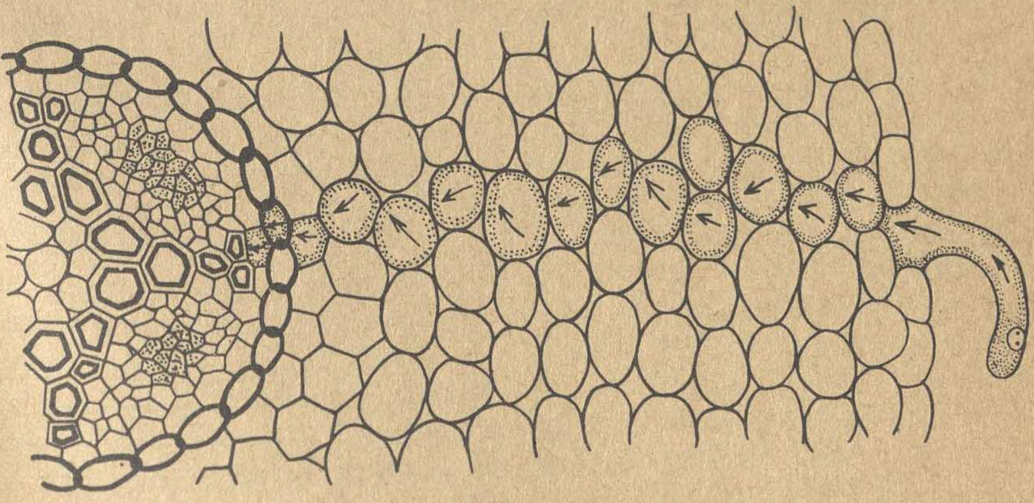

Fig. 8.2. *Absorption of water through root hair*

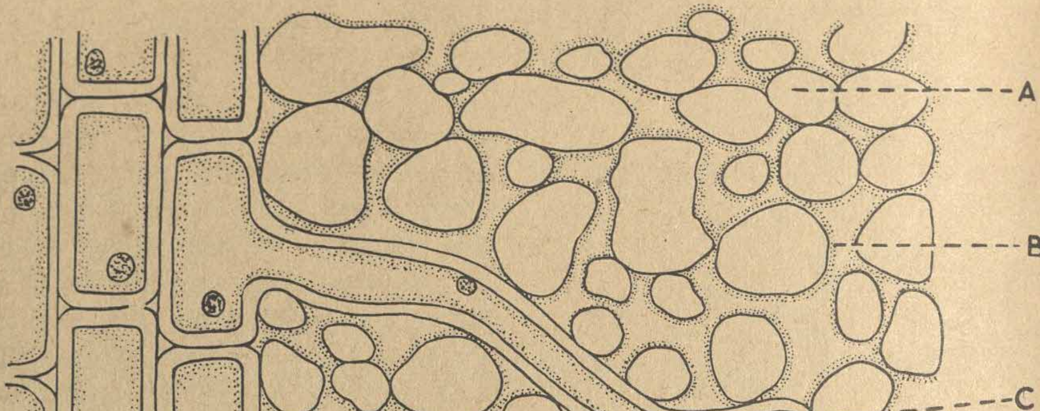

Fig. 8.3. Root hairs surrounded by soil particles and a thin film of water. A-soil particles; B-a film of water; C-root hair

and the mineral salt solutions absorbed by the root are carried upwards in the xylem of the stems. Ultimately, the water and the salt solutions reach the leaves through the petioles. In the leaf through the network of veins, the water reaches the green cells of the leaf blade. Thus the stem acts as a transporter of water and mineral salts to the leaves. Its other function is to provide mechanical strength in order to bear the weight of branches and leaves. In some cases stems also store food. In such cases the parts of the stem, which store food, remain underground and get modified into swollen parts containing starch.

Leaf and Preparation of Organic Material

The green leaves of the plant are so spread that they get maximum sunlight. what is the function of these green leaves which are found in such abundance ? We have already seen how the leaves manufacture food materials in their green cells. Thus the leaves are the most important parts of a plant. The plants are the only living organisms with the unique capacity to prepare their own organic food from the inorganic materials, water being absorbed from the soil and the carbon dioxide from the air. Carbon dioxide enters a leaf through the stomata and is assimilated inside the green leaves (Fig. 8.4). In this process, which is known as photosynthesis, a green pigment in the chloroplasts plays a very prominent part. The light splits up the water absorbed by the roots into hydrogen and oxygen with the help of chloroplasts. Part of the hydrogen combines with carbon dioxide in a complicated process. Sugar is produced. This sugar may be later on converted into starch. The organic matter thus produced in the leaf is transported to all parts of the plant where food is necessary. All cells and tissues use the organic food to get energy for their own life processes. For this, organic food is broken down into simpler substances with a release of energy. This process is known as respiration.

Respiration

Respiration is a process which takes place in all the living cells. Food materials like sugar are broken down with the help of oxygen. The final products of respiration are carbon dioxide and water. In this process energy is released and this energy is utilized by the respective plant parts to carry out their own functions.

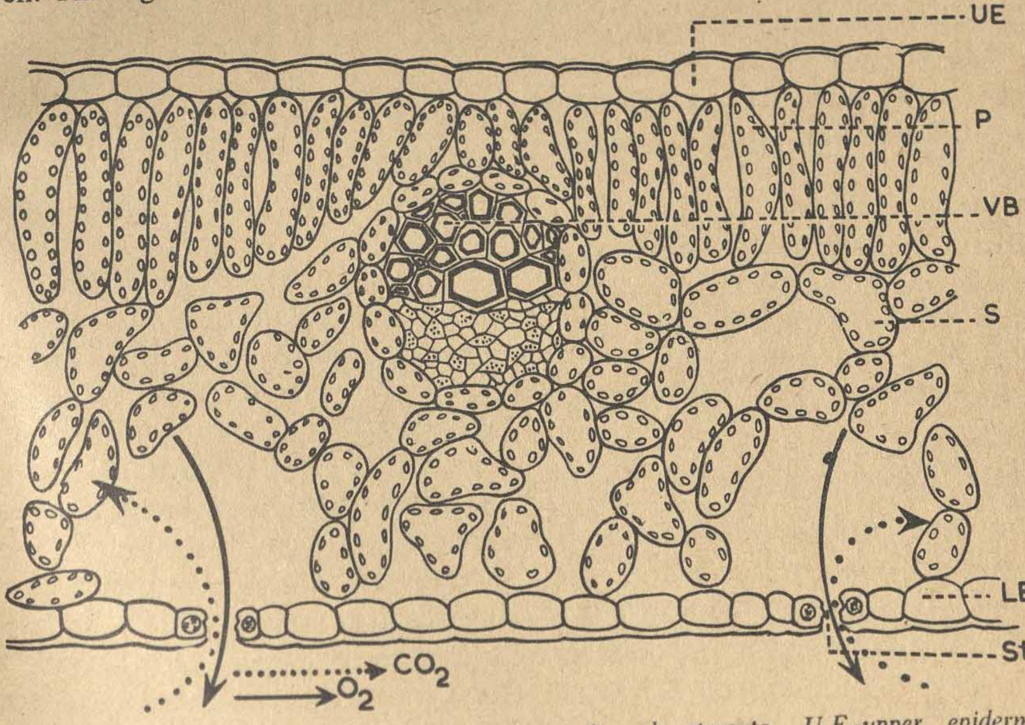

Fig. 8.4. *T. S. of leaf showing exchange of gases through stomata. U.E.-upper epidermis; P-palisade; V.B.-vascular bundle; S-spongy tissue; L.E.-lower epidermis; St-stomata*

The exchange of gases both in photosynthesis as well as in respiration takes place through the stomata in the leaves. Thus while the various physiological processes are carried out in different plant organs, respiration is a process which occurs in all living cells of all plant parts.

The Role of a Cell in Plant Life

We have already seen that the plant body and the plant organs are cellular in nature, that is, the organs consist of cells. Each cell has got protoplasm and nucleus. Different cells play different roles. The cell in the root, for example, the root hair (Fig. 8.2), absorbs water from the soil. The cells in the xylem of root and stem transport water physically towards the leaf. The green cells in the leaf have chloroplasts by the help of which the plants are able to convert carbon dioxide and water into sugar. During this process oxygen is given off.

During the life of a plant, the cells divide many times to form new tissues. These tissues may give rise to special organs. Cells dividing at the tip of shoots and in the axillary buds increase the tissues of the plant which results in growth.

Growth of Plants

Growth is an important feature of life. It is easy to see growth in the young plant such as a seedling. In a plant all the organs grow. Sometimes the stem grows enormously in thickness also. The trees like the banyan and eucalyptus grow to very great heights and the thick **lianas** grow to enormous lengths. The growth of the plants is the result of continuous cell divisions which adds to new tissues and organs.

Movement in Plants

Many flowering plants do not show obvious movements. But there are slow movements which, if one takes care, can be observed. Some plants which are placed near a window turn their shoot towards the source of light after a few hours. The opening of a flower is due to movement. The twining of a creeper round a support is also due to movement. All these movements are brought about by differences in the growth of certain cells in particular regions.

Reproduction in Plants

After growing for some time, the plants produce flowers. We have observed how the flowers in turn produce fruits which contain seeds. The flowers are important structures for bringing about reproduction in plants. By means of reproduction the plant increases its own variety and thus maintains an increase in its numbers. The seeds that are produced within a fruit are the result of the union between male and female gametes. These gametes are found in the flower.

The union between the gametes is fertilization. As a result of this the egg cell in the ovule develops into the embryo and the ovary becomes a fruit. The seeds are dispersed by various methods in nature. The fleshy edible fruits are eaten by men and animals and the seeds are dispersed. The berries are similarly eaten for their fleshy part and the seeds pass out unaffected from the digestive tract of the birds or animals. There are seeds or fruits with spinous projections by means of which they attach themselves to cattle or man's clothes and get dispersed. Seeds of cotton have got fibres on them. In *Calotropis* the seeds have a parachute like mechanism which keeps the seeds floating in the air. Some fruits like the coconut, float in water to distant places.

Reproduction is a significant event in the life of a plant. Plants reproduce, the new generation continues as a living organism.

Summary

The important events in the life history of a plant are, therefore, the germination of the seed, nutrition, assimilation, respiration, growth, development and reproduction. Plants are endowed with the capacity to perform all these processes. Some plant organs do only particular work but the plant exists as an entire living organism.

Questions

1. What are the different types of growth in a plant ?
2. What type of movement does a plant show?
3. Which are the organs of a plant that take part in the nutrition of a plant?
4. Name the different organs of reproduction in plants.
5. Explain the process of respiration in the plants.

§ 2. Conditions Necessary for Plant Life

For good growth a plant needs suitable conditions of soil, moisture, air, temperature and light. Each plant has a particular demand of these factors. As different places have different sets of conditions, the plants growing in these places also differ in their nature.

Plants and the Soil

The growth and development of plants are very much influenced by the type of the soil. Different kinds of plants grow in good or in bad types of soils. There are some hardy plants which can grow in a bad type of soil, even when it is too sandy or too clayey. *Agave* grows in arid and sandy regions. *Portulaca* and *Hygrophila* can grow in extremely clayey soils. In comparison to these plants, common trees like mango or plants like *Ricinus* or papaya need good soil to grow. For economic cultivation, food crops or fruit trees require good soil. The roots of plants should have good air inside the soil. Therefore, the soil should be porous and at the same time contain enough moisture and mineral salts for the plants to grow. The soil must have a good structure and should be able to preserve water and mineral salts in solution needed for the nutrition of the plant. When we grow plants for big leaves, such as salads, spinach, cabbage, etc., the soil, in which such plants are grown, must be rich in nitrogenous salts. On the other hand, plants like potato or radish which store food material in their underground organs, are grown in a soil rich in potassium salts. For peas and other leguminous plants, and tomatoes which provide mankind with a rich source of protein and vitamins, phosphorus and nitrogenous soil is best suited.

Plants and Water

Most plants absorb water in excess of what they need. The excess water is lost through transpiration. Roots absorb minerals only in the form of solution. Water is needed for transportation of food substances through all plant organs. Water provides turgidity to the cells.

Different plants require different quantities of water. The cacti which are desert plants need very little water. Plants on mountains like the ferns or pine trees do not need much water.

Of the cultivated crops, crops like paddy, jute, etc., need plenty of water in the soil. But wheat does not need so much water.

Plants and Air

We know that without air a plant cannot grow. Carbon dioxide present in the air only in small quantity (0.03 per cent) is sufficient for the nutrition of all the green plants of the world.

Plants also need oxygen. The oxygen is needed for the respiration of the

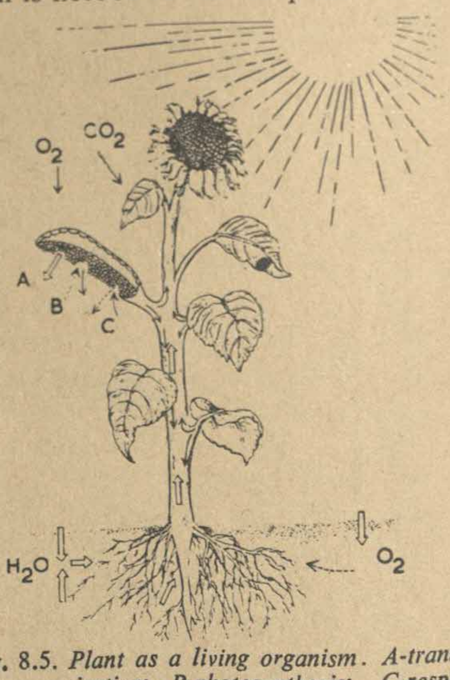

Fig. 8.5. Plant as a living organism. A-transpiration; B-photosynthesis; C-respiration

plant. If plants do not get sufficient oxygen, their respiration suffers and growth does not take place. All germinated seeds require a good supply of oxygen. When seeds are germinated in soil in monsoon, oxygen is not able to penetrate the soil due to the fact that water is covering the soil. Therefore, seeds sown below the surface of the soil do not get a supply of oxygen and may germinate poorly or even may die. All plant organs, for instance, the stems or the leaves, need oxygen.

Plants and Light

Plants get light from the sun. Without sunlight green plants cannot manufacture food. Different plants need different amounts of light and illumination. Some plants need a good amount of light and are called light plants. Others are shade-loving plants. The light-loving plants are the pipal, the banyan, the neem and the silk-cotton trees. Shade-loving plants are *Crotons*, *Coleus*, *Alocasia*, turmeric, etc. Many cultivated crop plants or vegetables need direct sun, for example, paddy, sugarcane, jute, potato, spinach and beet. On the other hand, there are cultivated plants such as ginger, gourds and betel plants which require shade.

Summary

Plants require certain conditions of soil and environment for their growth. These are light, temperature, water, mineral salts, air. Plants absorb water and minerals in solution from the soil and carbon dioxide and oxygen from the air. How much of these each plant requires may vary. A good farmer must know the best conditions and factors necessary for good growth of a particular plant before he ventures to cultivate it. A good growth alone can give him high yield.

Questions

1. What are the conditions necessary for plant life ?
2. In what way is light useful to the plant ?
3. Name some sun-loving and some shade-loving trees or plants.
4. What is the role of water in the life of the plants?
5. What are the substances in the soil or water or in the air, that are required by the plants for nutrition ? From where do the plants get their nutrition ?

CHAPTER IX

FAMILIES OF FLOWERING PLANTS

§ 1. Classification of Plants

We see plants all around us. The plants are found in dry areas, in moist regions, in lakes, in sandy places and almost everywhere. All plants are not alike. Some are big, some are small, some have hard woody stems, and some have soft stems. Man calls plants by their names, e.g., banyan, neem, pipal, mango, etc. Formerly plants were divided according to their size and shape into trees, shrubs or herbs. For a good understanding of different plants, it is necessary to divide them into natural groups. This division of plants into groups is called **classification**. The classification of plants helps a biologist to understand a plant better.

Suppose all your books are mixed up and arranged without any order on the shelf. You would be confused and find it difficult to pick out the book you want. If some one arranges your books according to the subjects, it is easy for you to refer to the books. If you get a new book, you would at once know from its subject where and in which group to place this book on the shelf. Similarly, we find the types of flowering plants in such large numbers that at first it is bewildering. But plants have been divided into groups from early times. In the 18th century, Carolus von Linnaeus grouped plants according to their natural relationships. Later on, other scientists improved on these methods, and now plants are classified into well-marked groups. In each group are included plants which have similar characters like shape, external or internal structures, similar places of occurrence and similar methods of reproduction.

Dicotyledons

Flowering plants are divided into two big groups, the dicotyledons and the monocotyledons. The seeds of dicotyledonous plants have embryos with two cotyledons such as you have examined in a bean seed. When you open a soaked seed, the two fleshy structures seen are the cotyledons. Other dicotyledons are the pea, the neem, the banyan and a good number of flowering plants. Their leaves are generally broad and have network-like (reticulate) venation.

Many fruit trees like mango, jack, sapota and apple are dicotyledons. The pulses like bean, peas, *arhar*, *urad* are all dicotyledons.

Monocotyledons

You have also examined a soaked maize seed. The embryo in this has only one cotyledon. All plants whose embryos have one cotyledon are monocotyledonous. The leaves in these are generally linear and have parallel venation.

Wheat, maize and rice are all monocotyledons. All grasses belong to this group. Onion, ginger and *Amaryllis* are also monocotyledons. There are also many wild plants belonging to this group.

§ 2. Families of Flowering Plants

We have seen in the preceding section that the plants are divided into dicotyledons and monocotyledons. These groups are large and are divided into smaller groups and these into still smaller groups called **families.** The wheat plant has so many features common with maize and rice plants. All these plants are grouped under one family, the Gramineae. The *bhindi*, the cotton, the china-rose and the hollyhock have several common features, particularly in the nature of their flowers. All these plants are placed in the family Malvaceae.

Genus and Species

Families are divided into smaller groups or genera (singular—genus). All individuals which have some common characters are placed together in a category called **species**. The cabbage and cauliflower are varieties of one species. The mustard belongs to another species. But some characters are common between the cabbage and the mustard, *i. e.*, between the two species. The two species are placed in a higher category known as genus. A genus is a collection of closely related species. The orange, the lime and the lemon represent different species but belong to the same genus. Similarly different genera have some common characters between them and are placed in one family.

We usually have common names for plants. But there are so many plants whose common names we may not know. The same plant may be called by one name in one region and by another name in a different region. In order to convey a precise meaning scientists have given some names to the plants by which they know them. The name of each plant consists of two words; the first is the name of genus and the second is the name of the species. The names are generally in Latin. In those days when this system of naming the plants was started Latin was popular and was considered scholarly. Every scientist knew enough Latin. A name given in this language could be understood by everyone.

When we want to identify a new plant we usually refer to books called **floras.** These books have a list of names with brief descriptions of all plants found in a region.

Questions

1. What are the typical features of monocotyledons and of dicotyledons?
2. Why are plants named in Latin? Why do they have two names ?

§ 3. Malvaceae

This family includes many useful plants. The cotton plant which yields the valuable cotton fibres for the manufacture of cloth, belongs to this family. The *bhindi*, china-rose (shoe flower) and hollyhock are other members.

The Cotton Plant

The cotton plant is a large woody shrub growing to a height of 1-3 metres. When cultivated as a crop the plant is an annual. The leaves are large and three-lobed. They occur one at each node.

The flowers are large and yellow in colour. They occur in the axils of leaves (Fig. 9.1). Each flower has five green sepals and five large coloured petals. The petals are so placed with overlapping margins' that they form a shallow cup-like structure. Besides the sepals and petals the flower bears many green leafy structures outside the sepals.

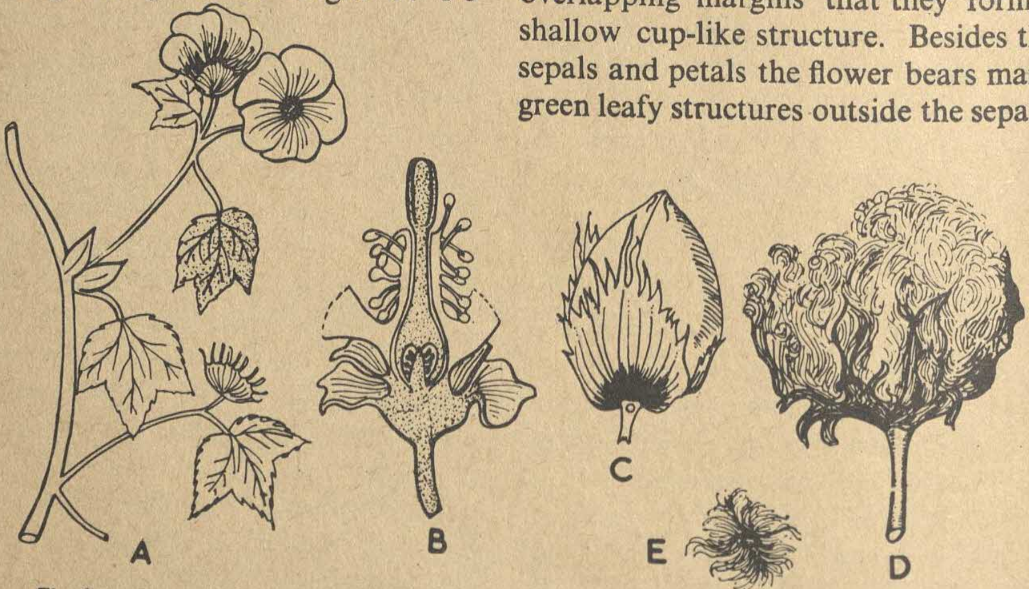

Fig. 9.1. Cotton plant. A- flower; B- t.s. of flower; C-boll; D-open boll; E-fruit

In the centre of the flower is a column-like structure. This is made up of all the stamens fused together. On the tube are situated many anthers. This tube-like structure surrounds the pistil which is situated in the centre. The pistil consists of a box-like structure at the bottom, which is the ovary. The ovary has 3-5 chambers. Each chamber is separated from the next by a partition. In each chamber there are many ovules. On top of the ovary is the thin style ending in a stigma which has five branches each ending in a sticky head.

After fertilization, the ovary develops into a fruit. When mature, the fruit cracks open exposing tufts of fluffy cotton fibres. These are known as **bolls.** All the fibres constitute the cotton lint. Cotton is very widely used. It is used to make clothing. Textiles—the manufacture of cotton cloth–is a major industry in India. Cotton is also used in stuffing mattresses. After the removal of lint, an oil is extracted from the seeds. This oil is very useful. The refined oil is used in cooking and in soap making and the oil cake is used as cattle feed.

There are other useful plants in this family. The *bhindi* plant yields the summer vegetable, *bhindi*. This vegetable is available in all parts of the country. Another plant is *Hibiscus rosasinensis*, the shoe flower or the china-rose. It is grown in gardens. The plant is a shrub. It has simple leaves with toothed margins. The flower is typical of the family.

The China Rose

The flower has a bunch of green leaf-like stuctures. After this, there is a ring of five green sepals. Inner to the sepals are the five attractive red coloured petals. The margins of these petals overlap, so that all petals appear to be twisted. All petals together form a cup-like structure. There are several stamens which are united to form a tube (Fig. 9.2). This tube bears on its surface many anthers. Examine the anthers with a lens. What is the shape of an anther? You will find that the anthers are bean-shaped. The staminal tube encloses the pistil inside. The pistil has an ovary at the base, a long slender style which branches at the tip to form five lobes of stigma. The surfaces of the stigma are sticky to touch, The ovary has five chambers each with several ovules.

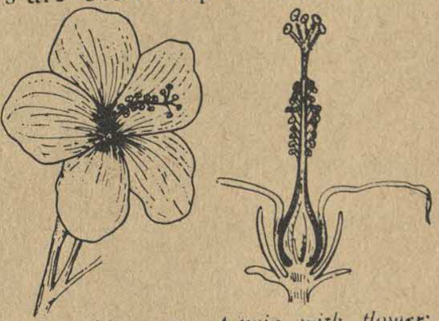

Fig. 9.2. China rose. A-twig with flower; B-L.S.-flower

Hollyhock (*Althaea rosea*) is another ornamental plant grown in gardens.

Characteristics of the Family

The plants of this family are herbs, shrubs or trees. Leaves are simple with palmate veins. Flowers occur singly. The flowers have all the floral parts. There are five sepals, five petals, numerous stamens and an ovary with five chambers. The stamens are all united into one bundle forming a tube. The tube surrounds the pistil. On the wall of this tube the anthers are attached by a short stalk. In addition to sepals there is a whorl of leafy structures on the outside which are called epicalyx. The fruit is a capsule. When dry it splits open. In some plants the fruit will not split.

§ 4. Leguminosae

This is a very large family having several members. There are sub-families in this group. The one common feature among all is the fruit, which is a legume. The fruit is long and flat with the seeds attached to one margin. There are several useful plants belonging to this family. The bean and the pea plants belong to this family.

The Bean Plant

The plant is a twiner. Its stem is very weak and it climbs over supports by turning around them. The plant belongs to Papilionaceae, one of the sub-families.

The leaves are compound with three leaflets. The flowers occur on special branches which are racemes.

The flowers are large. There are five sepals. The five petals are not equal in size. Two petals appear to be attached by one edge and look like the keel of a boat. There are two petals on either side of this keel and one large petal hangs over all these. This petal is called the **standard**, the two side petals the **wings** and the two lower ones the **keel**. The whole shape of this flower is known as **papilionaceous**. This shape is particularly suited for the visit of an insect. It alights on the standard petal or one of the wing petals. There are ten stamens. One is free while the other nine are united to form one bundle. The pistil is in the centre. It consists of an ovary which is long and flat, a small style and a stigma at the end. When the ovary is opened it shows several ovules attached to one margin.

After pollination the flowers shed their sepals, petals and also the stamens. The pistil alone remains and becomes bigger and bigger and ultimately the ovary becomes a fruit enclosing the seeds. In bean plant, the fruit is elongated and flat. This is called a **legume**. If it is opened it will show seeds attached to one of the margins.

You have already examined the structure of the bean seed. It has a seed coat and an embryo inside. There are two prominent fleshy cotyledons. Between them at one end is the tiny plant consisting of a plumule and a radicle. This tiny plant together with the cotyledons constitutes the embryo.

The Pea Plant

Other plants of the family have many of the structures described above. The flower particularly has the same structure. The pea plant has all these structures. The pea plant is a climber. (Fig. 9.3). The leaf is compound with many leaflets arranged on either side of a leaf stalk. The end leaflets are modified into spirally coiled structures called **tendrils**. These tendrils coil round some supports and help the plant to climb.

Characteristics of the Family

This family is a very large one and consists of three sub-families. These are : (*i*) Papilionaceae (*ii*) Caesalpiniaceae and (*iii*) Mimosaceae.

The plants of this family may be trees, shrubs, herbs, climbers or twiners. The leaves are simple or compound and their petiole bases are swollen. The leaves often appear to go to sleep in the darkness. Actually the leaves fold over or droop. The most common character of the three sub-families is the fruit which is a legume. A legume is a flat one-chambered fruit with all the seeds attached to one margin.

The other characteristics of the sub-families are as follows :

(*i*) Papilionaceae

Petals of the flower are so arranged that the shape is said to be papilionaceous. The petals are all not of the same size. There are ten stamens in

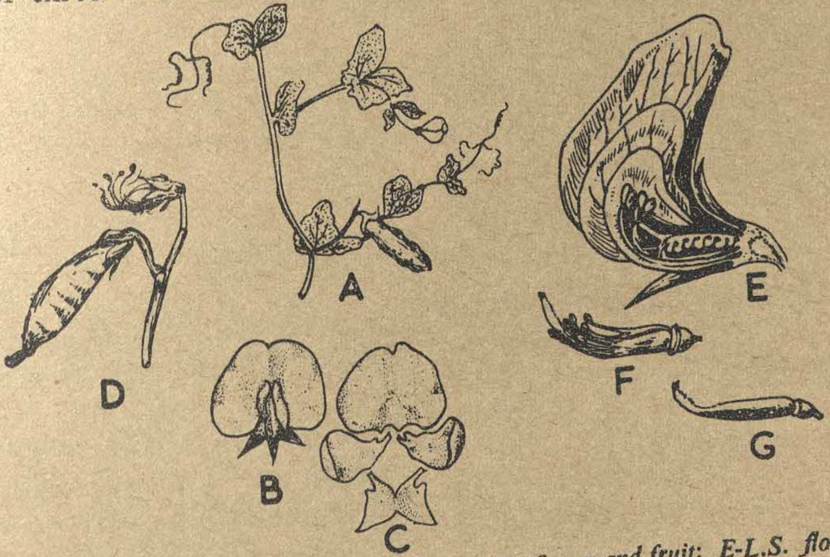

Fig. 9.3. Pea plant. A-twig; B flowers C-petals; D-flower and fruit; E-L.S. flower; F-stamen; G-pistil

the flower. Usually one stamen is free while all the others are united. The ovary is one-chambered with a number of ovules attached to one margin. The fruit is a legume.

(*ii*) Caesalpiniaceae

The plants are trees or shrubs. The leaves are compound and the main stalk or **rachis** and the secondary rachii are all **pulvinate** (swollen) at the base. All leaves show sleep movements. Flowers are symmetrical and the petals are all of equal size. The stamens are ten or more in number. The ovary and the fruit are similar to those in Papilionaceae.

(*iii*) Mimosaceae

The plants are trees or shrubs. Often there are spines on the branches. Leaves are compound. Flowers are small, regular and collected in head type of inflorescences. The fruit is a legume.

The Leguminosae is a very large family. It includes several important plants.

All pulses or *dals* and many vegetables belong to this family. The bean and pea have already been mentioned. *Arachis hypogea* is the groundnut plant and the seeds of this yield oil. There are timber trees like *shisham*, and red sandal-wood in this family. *Acacia* and *Prosopis* are thorny trees, belonging to this family and growing usually in dry regions.

Usually the land where the leguminous plants grow become richer and more fertile. The roots of these plants have nodules, which are swellings on the root. Bacteria live in these nodules. These are capable of fixing atmospheric nitrogen. No other plant can use the free nitrogen of the air. Usually all plants can absorb nitrogen as salts containing nitrogen. But the bacteria are able to fix nitrogen and make it available to the leguminous plants. When these plants die they make the soil richer in nitrogen.

§ 5. Compositae

This is the largest family among flowering plants. The plants are widely distributed and found everywhere.

The Sunflower Plant

The plant is a herb with a woody stem. The leaves are large and simple. The flowers are in head inflorescences (Fig. 9.4). The inflorescences occur in the axils of leaves or at the terminal point of the plant. The inflorescence has a number of bracts at the base. The flowers in the head are of two kinds. Those along the outer rim have long narrow strap-shaped petals. These are **ray florets.** The central flowers are called **disc florets.** The disc florets have

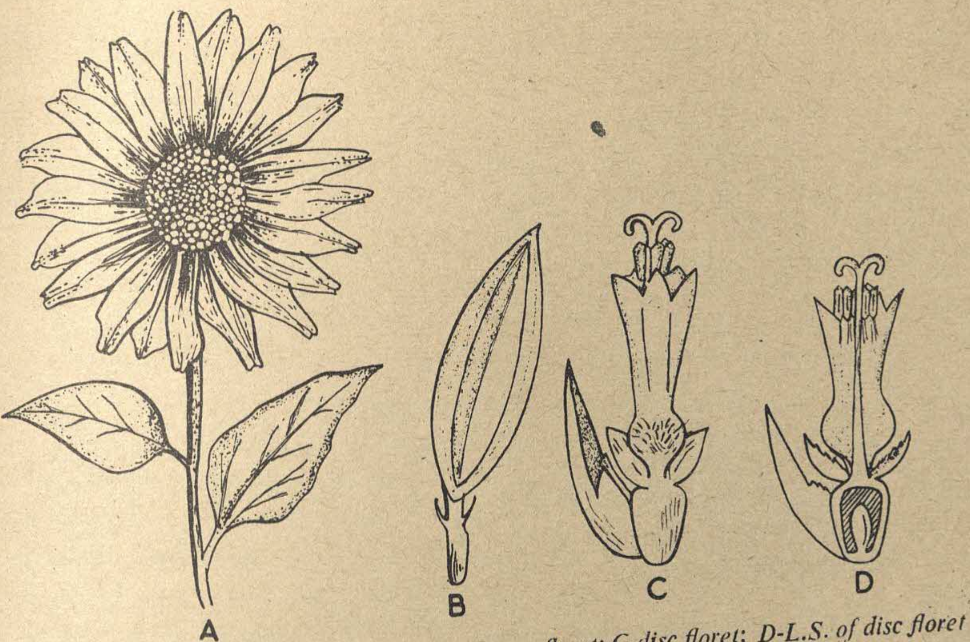

Fig. 9.4. Sunflower plant. A-twig with flower; B-ray floret; C-disc floret; D-L.S. of disc floret

a tubular corolla (all petals together are called corolla).

The mass of florets collected in a compact manner gives the inflorescence a huge flower-like look. Actually it consists of several flowers. An insect coming in search of nectar walks over the head and effects pollination of several flowers simultaneously. The small structure at the base of each floret is the ovary containing one ovule. Later this part becomes the fruit. There is one seed in each fruit. The seeds in the fruits have plenty of oil. In some countries, oil is extracted from a variety of sunflower seeds. The oil is used for cooking.

The plant lives only for one year. After forming the seeds, the plant dies. Thus the plant is an annual.

Characteristics of the Family

The plants are all herbs. The leaves are simple. The inflorescence is a head inflorescence. It is characteristic of the family. The flowers are all small and are called florets. They are crowded together. In each floret the sepals are reduced to scales or hairs. Petals are five in number and are united to form a tube. In the ray florets the petals are united and are strap-shaped. There are five stamens. While the filaments of these are free from each other, the anthers are all united. The pistil consists of an ovary which is one-chambered with one ovule, a style and a stigma with two lobes. The ovary is placed well below the sepals and petals. Such an ovary is said to be **inferior.**

Many weeds belong to this family. When the seeds are ripe and dry, they float about in air because of the presence of hair-like bristles at the top. These are the rudimentary sepals. These appendages help the seeds to be dispersed in the wind far and wide. This is one of the reasons why the family is so wide-spread. There are several ornamental members of the family like the asters, chrysanthemums, cosmos, marigold and zinnia.

Among useful plants are the sunflowers, whose seeds yield edible oil. Salad plant (*Lactuca sativa*) and the Jerusalem artichoke (*Helianthus tuberosus*) belong to this family.

§ 6. Solanaceae

This is an important family of flowering plants which includes several vegetables, drug and ornamental plants. The brinjal (*baingan*) belongs to this family.

Brinjal *or Baingan* (*Solanum melongena*)

The plant is a large herb covered with hairs. The stems are thick and hairy. Flowers occur singly or in small groups opposite the leaves. The sepals in the flower are united showing five sepals in the form of five triangular lobes (Fig 9.5). The sepals do not fall off but persist in the fruit. The corolla (petals) is united at the base and has with spreading lobes. These are purplish-violet in colour. There are five stamens whose filaments are actually fused with the petals. The anthers open by apical pores. The stamens alternate with petals in their position.

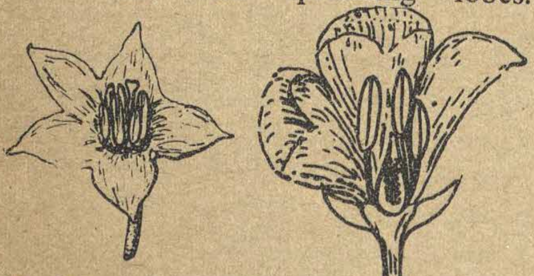

Fig. 9.5. Solanum species. A-Flower; B-L.S. flower

The ovary is two-chambered. After fertilization, it develops into a fleshy fruit. The fruit is called a berry, where the bulk of the portion is fleshy and the seeds are embedded in this fleshy part. When the young fruit is cut across, you can see the seeds attached to a central fleshy part.

Tomato (*Lycopersicon esculentum*)

This is a popular vegetable plant. Tomatoes are used in the preparation of sauces and ketchups.

The plant has a weak trailing stem covered with hairs. There are many alternate, compound leaves (Fig. 9.6). The flowers develop opposite the leaves, either singly or in clusters. The number of sepals and petals is six (though five is the normal number in the

Fig. 9.6. *Tomato Plant*

family). Petals are yellow. The six stamens are attached to the corolla tube. Anthers are long. The ovary is made up of two united carpels. The fruit is a berry, reddish or yellowish, with a smooth skin. The fruits are used as salad, vegetables and for the manufacture of tomato sauce.

Characteristics of the Family

The plants of this family are herbs or shrubs. Leaves are simple. Flowers occur singly or in clusters. Flowers are regular and have both stamens and pistil. The sepals are united and have five teeth-like lobes. They persist in the fruit. The petals are also united at the base and the corolla tube has five teeth-like lobes. There are five stamens, whose filaments are fused with the petal lobes. The ovary is made up of two carpels and is two-celled. Ovules are many and are attached to a central fleshy part. The fruit is mostly a berry.

Useful Plants

The family includes many useful plants. The two already mentioned are the brinjal (*baingan*) and the tomato.

The potato is another important plant. This is cultivated only in cold temperate regions and on the hills. Some branches from the axils of lower leaves grow down into the soil and swell up into tubers.

The chilly is another important plant. Also called red pepper (*Capsicum frutescens*) this is used in cooking dishes and in pickles.

Tobacco is an important plant. The cured leaves are used in manufacturing cigarettes and cigars. Cigarette industry is a very extensive one in spite of the recent findings that smoking is not good for health and might lead to cancer of the lungs.

Many plants are poisonous and some of these are of medicinal importance (Belladonna). *Datura* is poisonous. Some ornamental plants grown in the gardens are *Petunias* and *Cestrums* or the night queen.

§ 7. Gramineae

This is a family of the grasses. Gramineae is a family with numerous economic plants. The cereals which are the principal food of man belong to this family. The ordinary grass serves as fodder for cattle. The grasses are the basic link in the food chain. Animals, including men, who eat only the flesh of other animals ultimately have grass as the basic link, because these animals which form the prey depend on vegetable matter for their food.

The Paddy Plant (*Oryza sativa*)

It is a plant grown under swampy conditions. It is an important food plant. Rice is eaten by people in the south and east of the country and by people in Kashmir and also in parts of Uttar Pradesh. It is the staple food of people in countries of south-east Asia.

The soil on which paddy is grown is clayey and is kept waterlogged. The stems are weak and erect. They are hollow inside. They produce a number of tillers or sprouts at the base. Leaves are long and alternate with a sheathing base, that is, the base of the leaf is broad and sheathing, surrounding the stem at the node. The leaves have parallel venation. The flowers are all carried in an inflorescence. The inflorescences in grasses and rice are compound ones.They are compound spikes. The main stalk is branched two or three times. The ultimate branches carry spikelets. Each spikelet has a central axis and one or two bracts at the base which have no structures in their axils. The third bract has a flower in its axil. This bract has another scale-like structure opposite to it. The flower has no sepals and no petals. Instead there are two fleshy structures called **lodicules.** The stamens are six in the paddy plant. The ovary is one-celled with one ovule. There are two styles which are feathery. The fruit is a caryopsis, *i. e.*, the fruit wall is fused with the seed coat.

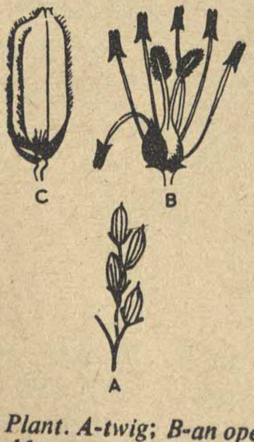

Fig. 9.7. Rice Plant. A-twig; B-an open flower; C-Paddy grain

In polishing rice in the mills the fruit wall is removed and sometimes the outer layer of the seed rich in protein is. also lost. This is very bad because important proteins and vitamins are lost and people eating such rice, suffer from diseases. In parboiled rice (a method by which paddy is partially boiled before milling) the vitamins and proteins are retained as they go deeper into the seed.

Characteristics of the Family

The plants are mostly herbs. A few like the bamboo, are shrubs. The stem is hollow except at the nodes. In sugarcane and jowar the stem is solid. The leaves are usually long and have parallel veins in them. The leaf bases are broad enough to cover the stem just above the node. Where the sheath joins the blade there is a small **ligule** or scale-like structure. The flowers are on compound spikes or **panicles**. Each spikelet has some lower sterile bracts and the top ones have flowers in their axils. The petals and sepals are usually absent. Instead, there are two fleshy growths called lodicules. Stamens are three or six in number. The ovary is single-chambered with one ovule. There are two feathery stigmas. The fruit wall is fused with the seed coat. All grasses are wind-pollinated.

Several useful plants belong to this family. Among the food plants are the important cereals and the millets.

CEREALS : Paddy, wheat, barley and oats.

MILLETS : Jowar, corn, bajra, ragi, etc.

From sugarcane stems the juice is extracted and jaggery and sugar are manufactured from this. Lemon grass yields a sweet smelling oil. The bamboo is a member of the grass family. The grasses are useful as fodder for the cattle.

Questions

1. Why is classification necessary?
2. To what family does the cotton plant belong ? What are the characters of the family?
3. Name some oil seeds and the family to which they belong.
4. Why is Gramineae an important family? What are the characters of the plants of this family?

Tasks

1. Collect useful plants of the different families and prepare herbarium sheets.
2. Observe the plants of the neighbourhood and note when they bear, flowers, fruit, shed leaves, etc.